NUCLEAR ENERGY

DECEMBER, 1960 THREE SHILLINGS & SIXPENCE

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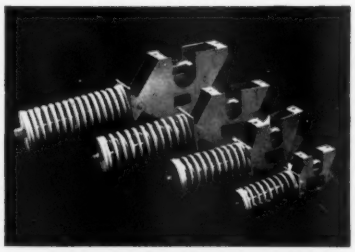
"I'm a belt and braces man, myself"

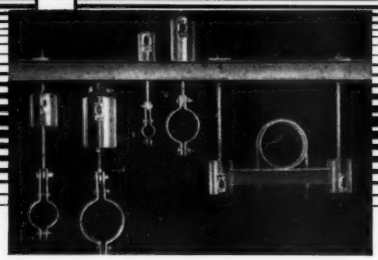
"Because I wear both, my mates reckon I'm a bit of a pessimist! But when it's a matter of essential support I'd rather be safe than sorry. Likewise, I've rigged enough to know that pipework suspended from Gensprings is never going to give any trouble. They use Gensprings on the big nuclear stuff!

This small one just above my head is an M2 Constant Support Hanger. There's a range of sizes to deal with loads from 315 lb. to 97,800 lb. Maximum deviation—if you need it this exact—can now be guaranteed at not more than 2%.

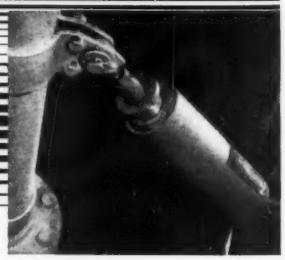
Then there are the Variable Supports for jobs less critical than those needing "Constants", and then again there are Sway Braces for damping out shock and vibration. I'm beginning to sound like the catalogues that Vokes Genspring will be glad to send you!"



Vokes Genspring 'M' Range Constant Support Hangers for supporting pipework and other high temperature equipment such as heat exchangers, furnace walls, condensers, etc. The constant supporting effort is equal to the weight of the pipework irrespective of thermal movements.



The Vokes Genspring range of Variable Supports covers travel ranges of 1½", 3" and 6", and there are 16 sizes in each range, covering loads from 58 lb. to 13,790 lb.



Vokes Genspring Non-Resonant Sway Braces can control all pipework subject to vibration and normal thermal expansion. Eight spring sizes cover loads from 39 lb. to 1,500 lb.

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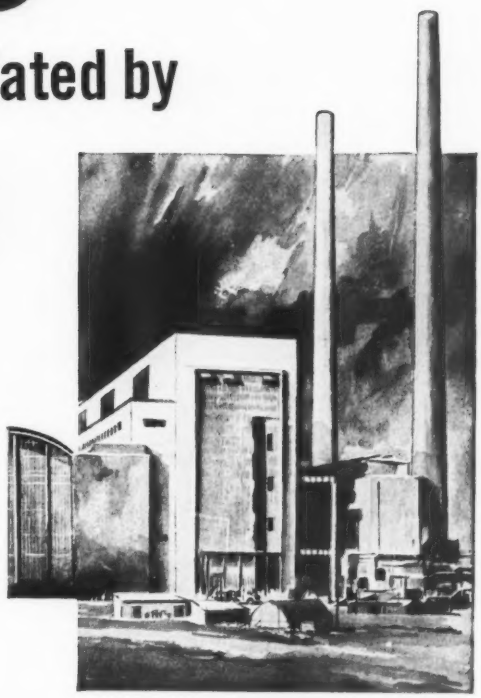

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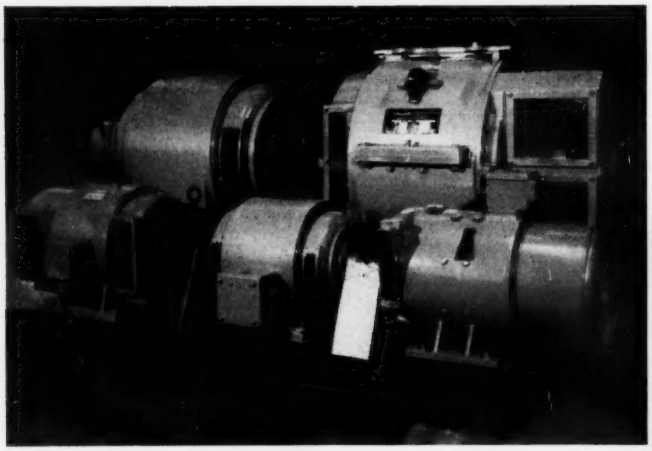

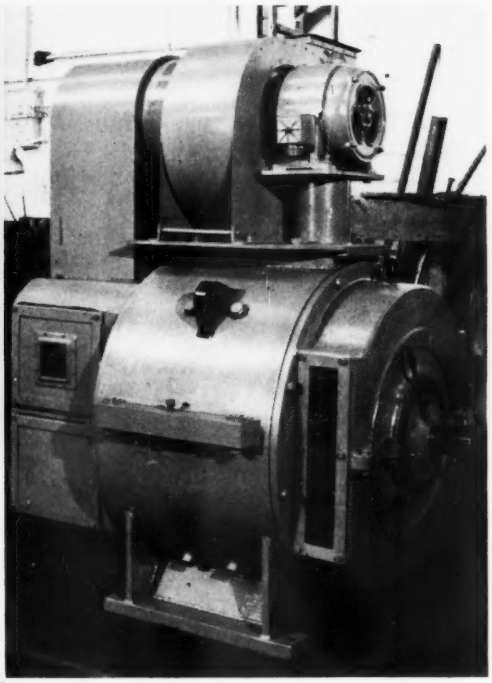

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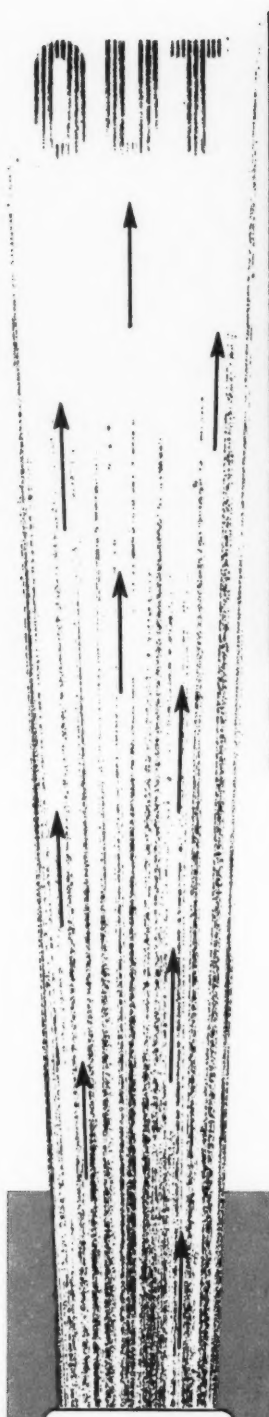

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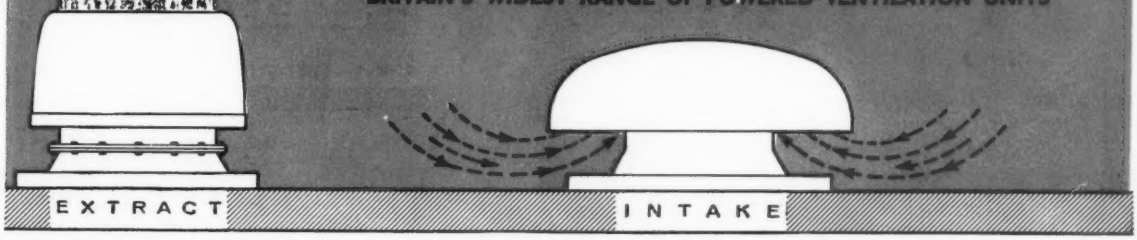

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The 56AVP is, in fact, an outstanding member of a distinctly outstanding range—the thirteen Mullard photomultiplier tubes, all of them providing unsurpassable performances, some of them unequalled in the world.

This range covers the spectrum from ultra-violet to near infra-red and three of the tubes incorporate a unique focused dynode system, providing their excellent transit time spread and rise time.

These tubes were introduced only after the most intensive development programme. In particular, the construction, arrangement and mounting of the secondary cathodes have been the subject of exhaustive studies aimed at producing a multiplier system giving a high current gain, minute dark current and minimum variation of electron transit time.

For so many applications

Employment in scintillation counting and gamma spectroscopy are but two of a very broad range of applications in which these tubes are used.

There is so much to be said . . .

about the 56AVP and the other twelve tubes in this range that you can gather all the necessary information only by studying the Mullard data sheets which will gladly be sent on request. Write now for these and for any further details concerning the Mullard photomultipliers and their applications. Here are brief details of the complete range

51UVP Eleven stage tube with 32 mm diameter photocathode and quartz end window to give sensitivity to ultra-violet.

52AVP Ten stage tube of 25 mm outside diameter and with 20 mm diameter photocathode.

53AVP Eleven stage tube with 44 mm diameter photocathode for use in gamma spectroscopy.

53UVP As 53AVP but with quartz end window to give sensitivity to ultra-violet.

54AVP Eleven stage tube with 111 mm diameter photocathode for flying spot scanners.

56AVP Fourteen stage tube with focused dynode structure giving rise time and transit time spreads of 2×10^{-9} s. 42 mm diameter photocathode.

56UVP As 56AVP but with quartz end window.

57AVP Eleven stage tube with large photocathode 200 mm in diameter.

58AVP Fourteen stage tube with 110 mm diameter photocathode. This tube has a tetrode input system giving spreads in transit time over the photocathode of 10^{-9} s.

150AVP General purpose ten stage tube with 32 mm diameter photocathode.

150CVP As 150AVP but with a photocathode sensitive to infra-red radiation up to 1.2 μ.

153AVP Eleven stage tube for use with scintillation counters giving a resolution of less than 9% with Cs^{137}.

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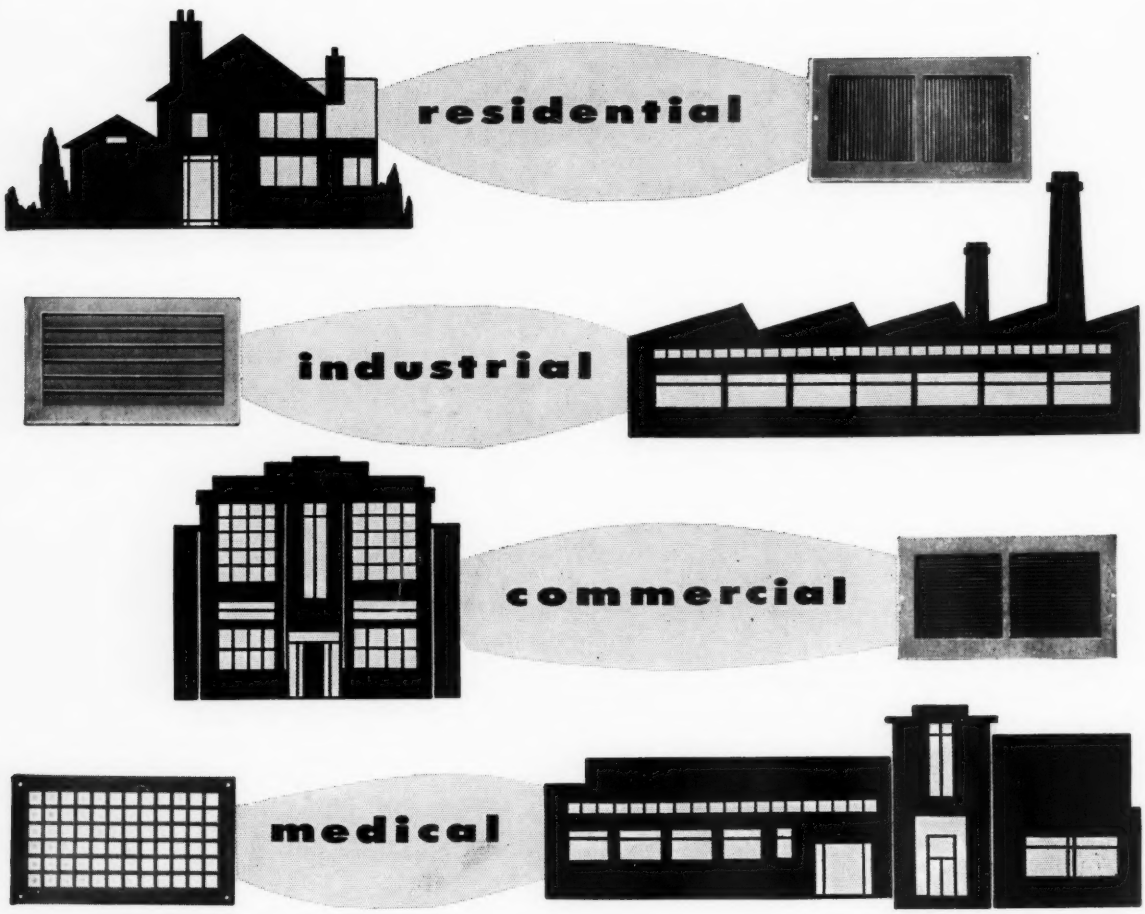

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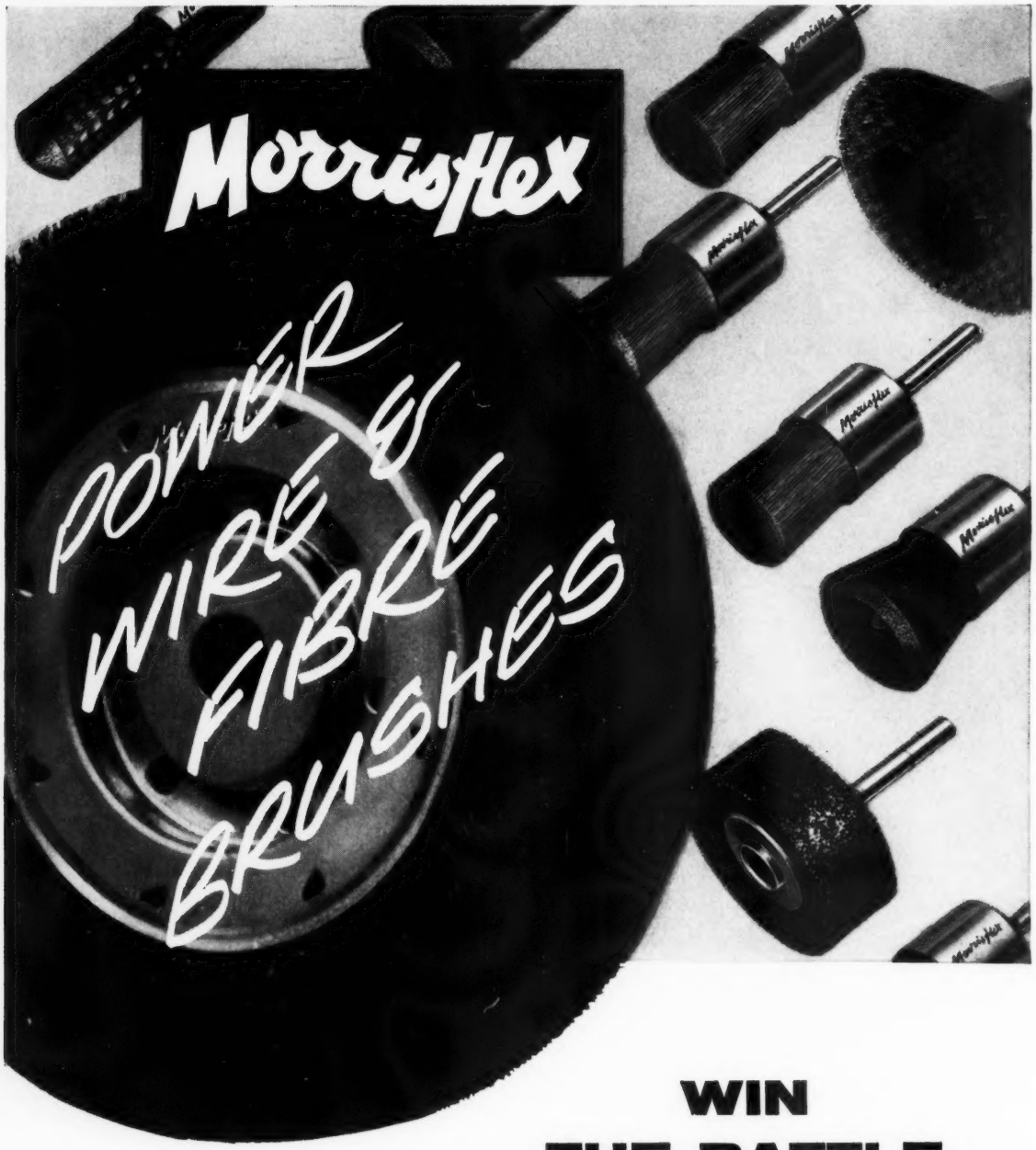

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WELL, WHAT IS IT?

(To be fair we should point out that the domed top and fabricated cantilever are part of a test rig. The thing in question begins at the weld below the lettering).

Unless you happened to see, in an earlier advertisement, the cardboard model in which the idea took shape, memory will be no help. This is something quite new.

It is an expansion joint, one of 72 such joints that will take up the expansion of the CO_2 ducting at the Trawsfynydd Atomic Power Station. Internal pressure 265 p.s.i., temperature 420 C.

The convoluted bellows holds the internal pressure; the end thrust—over 1,000,000 lb.—is taken by the inclined, high-tensile steel bars round the periphery; flexing is entirely by elastic straining of these bars. The illustration shows the joint being prepared for the Insuring Authority's acceptance test—1,250 full deflections under full internal pressure and temperature. Compared with previous joints for this kind of work it is lighter, simpler, cheaper. It is the kind of highly original solution to both new and old problems that Richardsons Westgarth engineers can, and frequently do, produce.

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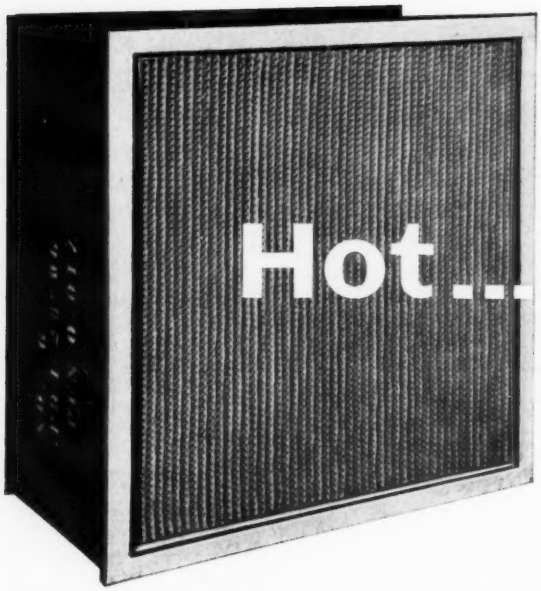
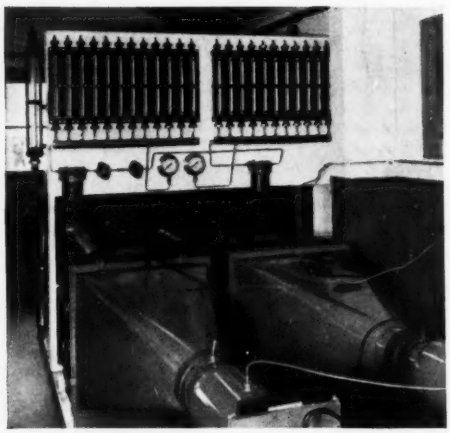


but not bothered

Vokes high temperature 'Absolute' filters



Vokes High Temperature 'Absolute' filters are tested in accordance with BSS. 2831 on the methylene blue test rig illustrated above. Every filter is subjected to a stream of air containing particles of methylene blue 'dust' ranging in size from 0·1 to 0·5 microns, and rejected if its efficiency is less than 99·99%. Vokes is the only British company which *guarantees* minimum performance figures in this way and Vokes filters are therefore widely used in all applications which require *scientific* filtration.

These filters have been designed for applications involving very high temperatures or risk of fire — for example in nuclear power stations where a breakdown in the filtration system due to an outbreak of fire might release dangerous toxic particles into the atmosphere.

They will withstand temperatures up to 1,000°F and are available in standard sizes as manufactured for the Atomic Energy Authorities. Similar in appearance to the 55 'Absolute' panels from which they were developed, Vokes high temperature filters have an all-glass paper filter medium with aluminium separators, refractory sealers and metal frames. The efficiency of this type of 'Absolute' is even greater than the very successful '55' panel, giving a penetration of only 0·01% against a methylene blue dust cloud.

A booklet on Vokes special purpose air filters is available on request.

The APPROVED filter for fire resistant applications

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NUCLEAR ENERGY

COMMENT

EURATOM is developing many close links with other countries and the field of external relations occupies an important share of the Euratom Commission's time and energies. There are both technical and political reasons for this. Technically, much depends on the extent of Euratom's co-operation with countries with more experience of nuclear problems: the Community is still well behind the U.S.A., the U.S.S.R. and the U.K. in the vast and quickly expanding field of nuclear technology, and Euratom's progress during the next few years will depend to no small extent on what can be learned from the more advanced nuclear countries.

On the other hand, Euratom is one of the three spearheads of economic integration in the European Community. Together, the three communities, Euratom, the European Coal and Steel Community and the European Economic Community (the Common Market) represent the most solid manifestation of unity yet achieved in Europe. But Europe cannot be wholly unified by the private efforts of the six Community countries alone. It is therefore an important feature of the Treaties of Paris and of Rome (which established the ECSC and Euratom and the Common Market) that the communities should be open to any European state prepared to accept the obligations of membership and the political aim of unity in Europe.

All in all, Euratom is co-operating with other free European countries through such inter-governmental organizations as the OEEC, with the world-wide international organizations and, not least, with individual countries through bilateral agreements.

Three agreements for co-operation have been signed between Euratom and non-member countries, with the United States, Great Britain and Canada.

The word " co-operation " hardly suffices to describe the importance of these agreements to Euratom in these early days. Taken together, the three agreements, along with the " Dragon " and Halden agreements, put Euratom's research programme on a far wider basis than would otherwise be possible, enabling Euratom to participate in various streams of reactor development, any one of which may provide the key to really low-cost nuclear power.

The U.S.-Euratom Agreement was signed in 1958. Its aims are perhaps best described by Euratom's president, Monsieur Etienne Hirsch: " the first aim was a political one...to strengthen, by a combined effort, the unity of Europe and the ties between this new European Community and the U.S. The second aim was an economic one; it was to add to the reactor experience already gained in the United States the experience of full-scale construction in Europe, where the cost of conventional fuel is higher. This effort was to be accompanied by a major research and development programme..." It hardly need be added that the Agreement is exclusively concerned with the peaceful use of nuclear energy. Indeed, it is underlined that co-operation should be dependent upon Euratom's satisfactorily applying safeguards and control arrangements to prevent the improper use of fissile materials supplied by the U.S.A.

The U.K.-Euratom Agreement was signed in 1959 for an initial ten-year period. The aim is " co-operation in the peaceful uses of atomic energy " between institutions and individual concerns in the U.K. and the Community. The main provisions are: the exchange of information and training facilities, the provision of nuclear fuel and reactors by the U.K., the establishment of two committees of representatives of the two Parties: one a continuing committee consisting of the president of the U.K. Atomic Energy Authority, a member of the U.K. government and a member of the Commission, the other a joint working group of officials of the UKAEA and the Euratom Commission.

The Canada-Euratom Agreements were signed in the same year: one agreement was with the Canadian government and the other, the technical agreement, with Atomic Energy of Canada, Ltd.

A Brazil-Euratom Agreement for co-operation between Euratom and Brazil has been drafted and has reached the final stage of discussion. A leading feature will be aid for Brazil's nuclear development, particularly for the training of technicians and for ore prospecting.

Altogether nine countries have diplomatic missions accredited to Euratom: they are the U.S.A., the U.K., Denmark, Israel, Norway, Sweden, Switzerland, Austria, Canada. Six more are expected to become accredited.

The Euratom Commission in the name of the Community, is establishing links with such agencies of the United Nations Organization as the World Health Organization, the International Labour Organization (with which the Commission intends to conclude an agreement on health and safety matters), the Food and Agricultural Organization and the GATT Secretariat; and, most important of all, the International Atomic Energy Agency at Vienna, and observers of the IAEA have been invited to attend conferences organized by the Commission and *vice-versa*.

In Europe, relations with the Council of Europe are maintained principally through the annual Joint Meeting of the Consultative Assembly and the Community's European Parliament.

All Euratom countries are members of the OEEC and its specialized agency, the European Nuclear Energy Agency, set up in 1958. The ENEA is working on two important research projects. The most important is the " Dragon " Project at Winfrith Heath, Dorset, England, for the construction of a high-temperature gas-cooled reactor. Euratom is very closely involved: like the U.K., it is contributing 43.4 per cent. of the total $38m. cost and more than 30 members of the Commission's research staff are working on it.

Lubrication Requirements of Nuclear Powered Surface Vessels

DESIGN CONSIDERATIONS

by E. H. Okrent

Esso Research and Engineering Company

This article considers the effect of nuclear surface vessel design on the functional requirements of lubricants. Toward this end, the critical design features of potential nuclear surface propulsion systems have been reviewed to determine the physical requirements imposed on the lubricant by the total environment, radiation being only one of the many factors to be considered. This review has indicated that the lubrication problems of nuclear propelled ships are similar to those of their conventional fossil-fuelled counterparts. Radiation stress, the main new environmental feature, is a consideration only in those components which are associated with the nuclear heat source (control rods, etc.), and then it is generally not a controlling consideration. The lubricants for the propulsion gear and its auxiliary systems present no new lubrication problems. However, leakage and primary coolant contamination requirements often take precedence in the selection of the lubricant or lubrication system

THE application of nuclear power to commercial power production and ship propulsion has placed a number of new requirements on conventional materials. Of these materials, the lubricants required for proper functioning of the numerous machine elements in the nuclear propulsion system are of prime importance, especially since both the safety and continued operation depends on well-designed lubricants.

Lubrication requirements

This article presents the results of a study of the lubrication requirements of nuclear powered surface vessels, which was conducted under a contract with the Nuclear Project Office of the U.S. Maritime Administration. This survey was initiated[1] to evaluate the lubrication requirements of nuclear powered surface vessels in the light of present and future designs[2] in order to determine if lubricants of enhanced radiation stability will be required for these systems. Part of this study has involved the identification of areas where information is limited and where additional research is needed. This study included a review of both the open classified literature in the areas of reactor design and radiation resistance of lubricants. In addition, nuclear propulsion system designers were contacted to assess present problems and estimate future needs.

An engineering approach was taken in this study, since lubrication cannot be divorced from power or propulsion system design. No discussion of lubrication, be it radiation stability or load-carrying ability, is possible without clearly established design requirements. This is especially true when new or unusual environments are encountered. Radiation stress represents one of these new environmental factors which must be evaluated with the other functional requirements of lubricant stability and "lubricity" in order to develop lubricants with an optimum combination of properties for the given application.

Stationary plants

Although this study was primarily aimed at nuclear surface vessel requirements, much of it is directly applicable to stationary nuclear power plants. In fact, the surface ship can be considered as a compact version of the stationary plant, but one that presents a somewhat more severe lubrication requirement.

The selection of a nuclear reactor for ship propulsion involves a large number of parameters. As a result, a number of reactor types appear to be applicable. These include pressurized water, boiling water, organic moderated, gas cooled, liquid-metal cooled, aqeuous homogeneous, liquid-metal fuelled, fast breeder, pressurized D_2O, and boiling D_2O. With a list this long, a discussion of individual plants, or even general types, would be too detailed for this

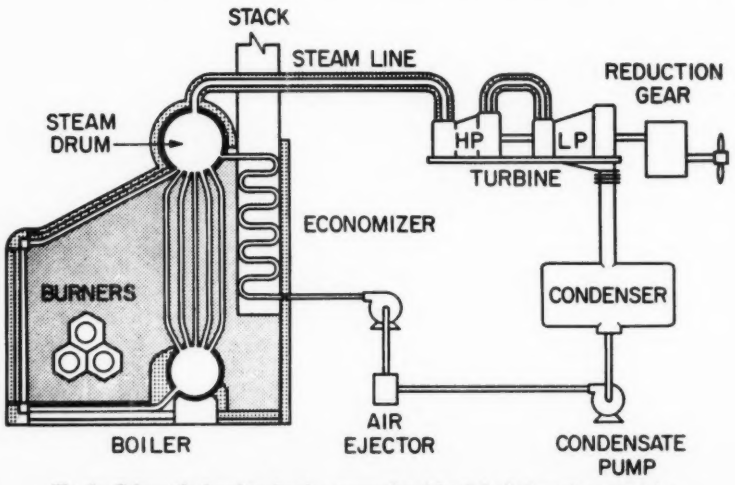

Fig. 1—Schematic drawing showing conventional fossil-fuelled marine propulsion generating unit

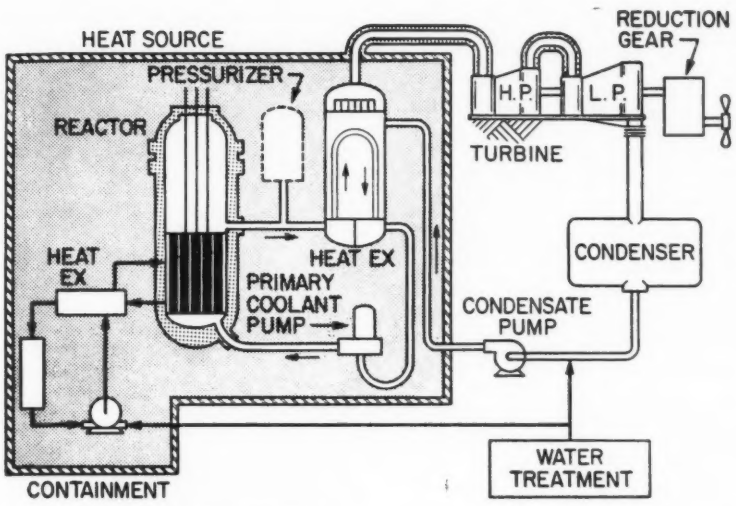

Fig. 2—Schematic drawing showing nuclear powered marine propulsion unit, indirect heat exchange system

article. However, portions of each of these designs will be discussed as it applies to lubrication problems.

Before discussing the lubrication requirements of a nuclear propulsion system, one must first examine ship propulsion systems, both conventional and nuclear, in some detail.

The modern fossil-fuelled steam propulsion system, as shown in Fig. 1, is composed of two parts—the heat source and the propulsion gear. The heat source includes such items as the oil-fired boilers, super-heater and the blower auxiliary system; the propulsion gear includes the cross-compound turbine, reduction gear and auxiliary condensing and feed system. Similarly, Fig. 2 is a schematic drawing of a nuclear propulsion system which indicates that the nuclear propulsion system may also be divided into these same fundamental parts: the nuclear heat source (reactor, steam generator, primary coolant pumps, etc.) and the propulsion gear.

Propulsion Gear

As can be seen, the propulsion gear in both the fossil-fuelled and the nuclear-fuelled systems is essentially the same. The major point of divergence of these two systems is in the heat source. In the case of the fossil-fuelled system, the furnace setting acts as a " containment " for the heat source and heat exchange equipment, whereas in the nuclear system, the pressure vessel, the primary and secondary shield, and the reactor containment vessel act as a container for the reactor and the primary coolant loop. From this rather elementary description, it is apparent that the lubrication requirements of nuclear powered surface vessels resemble the more conventional fossil-fuelled system. The only additional features encountered in the nuclear propulsion system are additional environmental factors of radiation stress within the secondary shield, new metallurgies and operation in contact with unusual fluids.

The propulsion gear and auxiliary condensing and feed system of the nuclear propulsion system (turbines, reduction gear, circulation pumps, feed pump, valves), do not present problems from a radiation standpoint.

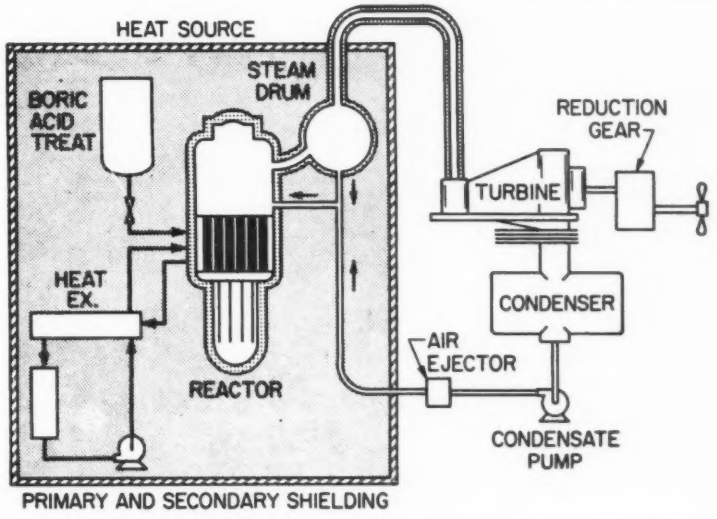

Fig. 3—Boiling water reactor direct flow system

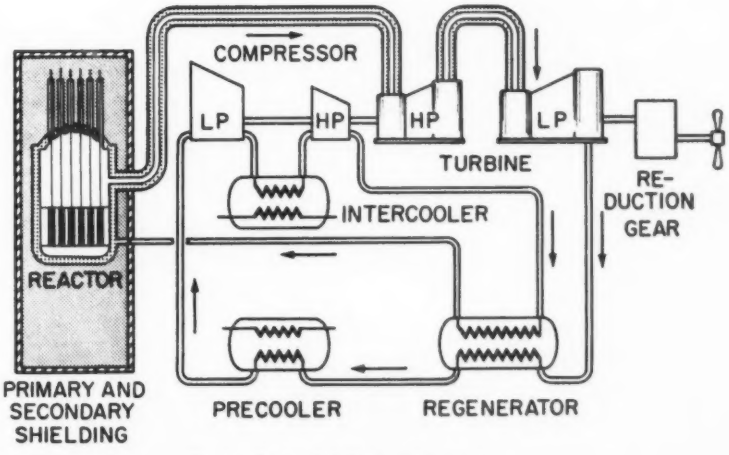

Fig. 4—Gas-cooled direct reactor system

Most nuclear propulsion systems are based on the concept of containment of the reactor and primary coolant loop. This containment and shielding complicates the problem of energy transfer and has led to a number of heat exchange systems. These can be divided into two basic groups, the dual fluid system (Fig. 2) and the single fluid system. Two versions of single fluid systems are shown, the boiling water system (Fig. 3) and the direct-cycle (Fig. 4) gas-cooled system.

In the dual fluid system, the working fluid never enters the reactor core and, therefore, has no residual radiation of its own. This is typical of the organic moderated reactor, the pressurized water reactor, the gas cooled reactor, the liquid metal cooled reactor, and the aqueous homogeneous reactor systems. The only source of radiation flux in the propulsion gear of these systems is that which leaks through the primary and secondary shielding. Since the propulsion machinery is generally accessible to operating personnel, the radiation flux levels should not exceed 0.1-0.5 rad/week. At this radiation level, no evidence of radiation damage will be evident during the useful life of the lubricants.

In single fluid direct-cycle propulsion systems, such as the boiling water and direct-cycle gas-cooled reactors, the problem is somewhat different, since the working fluid will enter the reactor core and will itself be activated. In addition, it can also carry radioactive erosion and corrosion products which generally have long-lived activity.

Measured Radiation

Table I summarizes some of the measured radiation flux levels in the propulsion gear and auxiliary condensing and feed system of the EBWR[3]. The estimated dose rate in the propulsion gear and machine space of General Electric's 22,000 s.h.p. boiling-water tanker proposal is shown in Table II[4].

In the case of the direct-cycle gas-cooled system designs, dose rate information is not as extensive since these designs have not reached the same state of development as the boiling water systems. However, in the helium-cooled MGCR system, the electric boat division of General Dynamics has estimated a dose rate at the turbine of 0.6 rad/hr (10^5 rad/20 years) for helium containing 0.1 lb/min Ar^{10}. In systems comparable to the MGCR but using other coolants, the dose rates would be somewhat higher.

Table I—Measured Flux in Propulsion Gear and Auxiliary Condensing and Feed System of the Experimental Boiling Water Reactor*

Component	*Dose Rate mr/hr*
Top of reactor	1
Sub reactor room	10
Steam dryer	150
Turbine inlet	50
Turbine casing	4
Condenser (above hot well)†	40
Air ejector after cooler	400
Feed water filters†	100
Ion exchange filters†	500–1,000

*VBWR reports similar figures.
†Feed pumps are located at this vicinity.

Table II—Estimated Dose Rate in the Propulsion Gear of 22,000 s.h.p. Boiling Water Tanker

Uncontrolled Areas	*Dose Rate mr/hr*
Machinery passageway (Forward of machinery)	0.07
Controlled Areas	
Turbogenerator	39
Turbogenerator cross-over Pipe	216
Demineralizer*	10

*15 min after shutdown, all others at full power.

Radiation dose rates in the propulsion gear and auxiliary condensing and feed systems are summarized in Table III. These data were obtained from discussions with designers, estimates from existing plants (stationary, surface and submersible) and from nuclear ship proposals. This table shows that the dose rates in the propulsion gear of nuclear-powered surface vessels are quite low, even in the direct-cycle gas-cooled and the direct-cycle boiling water systems. This point is emphasized more clearly when one compares the calculated and measured radiation dose rates with the 25 per cent. damage tolerance dose for conventional lubricants in low intensity fields. The first evidence of radiation damage to these materials would not appear for at least 30 years even in the most critical applications. Thus, it may be concluded that the lubrication of the propulsion and auxiliary condensing and feed system components does not present a radiation stability problem.

Deciding Factor

The deciding factor in lubricant selection will be such conventional factors as oxidation stability and load-carrying ability. Oxidation stability will be especially important to the long-term retention of lubricant properties since turbine lubricants operate between 140°F. and 200°F. under mildly oxidative conditions.

The nuclear heat source and its associated control and heat-transfer equipment are located within the reactor compartment. Some of the components that must be lubricated are within the secondary shield system, where radiation stress is a consideration. These components include pumps and compressors, control-rod drives, valves and valve actuators, motor auxiliaries and fuel-handling equipment. The following paragraphs will discuss the criteria for lubricant selection in these components.

A. Pumps and Compressors—The first of these necessary heat-source auxiliaries are the primary coolant pumps and compressors. This group

Table III—Estimated Radiation Dose Rates in the Propulsion Gear of Nuclear Powered Surface Vessels (Rad/week)

Component	*BWR*	*PWR*	*OMG*	*MGCR*	*LMC*
Turbines	8.16	0.1	0.5	100	Negligible
Cross-over	34–50	0.1	—	—	Negligible
Machine space	0.012	0.1	0.5	25	Negligible
Condenser	8–16	0.1	—	—	Negligible

Allowable Radiation Dose

People	0.15 Rad/week
Lubricants	
25 per cent. damage*	10^8 Rads
0 Damage	10^7 Rads

BWR=Boiling Water Reactor; OMR=Organic Moderated Reactor; LMC=Liquid Metal Cooled; PWR=Pressurized Water Reactor; and MGCR=Marine Gas Cooled Reactor.

*Dosage at which 25 per cent. change in a critical physical property has occurred, *i.e.*, viscosity, interfacial tension oxidation life, etc.

includes all of the pumps associated with the heat source (primary coolant, auxiliary, feed, etc.) The types of pumps available for these services are varied, making a discussion of specific requirements impractical. However, the basic lubrication requirements are identical with similar equipment in conventional power and propulsion systems. In addition to these conventional requirements, the nuclear system presents a number of unique requirements which must be considered.

Table IV—Estimated Maximum Radiation Dose Rate in Pumps and Compressors Associated with the Nuclear Heat Source (Rad/hr)

Reactor Type	*Primary Coolant Pumps or Compressor*	*Charge and Emergency Cooling Pumps*	*Purification Pumps*
PWR	10^2–10^3	60–300	1–5
BWR	10^2–10^3	60–300	1–5
OMR	Negligible	Negligible	Negligible
GCR	1–10	Low	Low
LMR	10^4–10^5	—	—

Lubricant Radiation Stability

0 Damage	10^7 Rads
25 per cent. Damage*	10^8 Rads

*Dosage at which 25 per cent. change in a critical physical property has occurred, *i.e.*, viscosity, dropping point, oxidation life, etc.

Well Below

Considering the first unique feature of the nuclear environment, radiation stress, the survey revealed that the radiation dose rates in these lubricated components are well below the limiting capability of conventional lubricants. This is particularly evident when one compares the maximum expected radiation dose rates in these components (Table IV) with the radiation resistance of conventional lubricants. (Table IV indicates that radiation stress is a consideration but not a limiting one. In these systems, conventional lubricant requirements will still be controlling).

In the liquid-metal cooled system, the maximum radiation intensity could place a strain on existing products. However, conventional lubricants cannot be considered for this service, because the operating temperature approaches 700-800°F., well beyond the capability of conventional lubricants. In this system, electromagnetic pumps and canned rotor pumps have found application. However, freeze-seal type pumps have been developed, which have shafts that extend through the shielding, so that the pump motor and bearings are outside the radiation flux. With this design, petroleum lubricants can be used to cool the liquid metal shaft seals and lubricate the drive motors.

Since radiation stress is not a limiting consideration, the question that naturally follows is how extensively are petroleum-based lubricants used in these primary coolant pumps? This question is answered in Table V, which summarizes primary-coolant pump lubrication in a number of nuclear power and propulsion systems being considered for surface-ship propulsion. This table indicates that organic lubricants are used only when primary coolant loop contamination is not a problem (or when it is provided for, as in the MGCR) or when zero primary-coolant leakage requirements permit. Thus, leakage and contamination requirements are apparently major criteria in pump lubricant selection.

Canned rotor pumps

For example, in the pressurized-water and boiling-water reactor systems, where radiation stress does not limit the use of petroleum lubricants, high cost water-lubricated (primary fluid) canned rotor pumps have been used. This type of pump was selected to avoid leakage of the primary fluid from the system and prevent the contamination of the primary coolant with lubricant which might leak in through the primary coolant pump seals. The designers believe that lubricant leakage would foul the heat transfer surfaces and cause subsequent failure of the fuel elements. No published experimental data have been found which define the allowable lubricant leakage requirement for water-cooled and moderated-reactor systems.

Lubricant leakage and contamination requirements are also important in the gas-cooled reactor systems. Here, petroleum oils are used to lubricate the primary coolant compressors or blowers and, in the direct-cycle system, the power turbine. Leakage of lubricant past the oil seals into the gas stream and leakage of primary coolant (gas) into the turbine or compressor lubricants are important problems. There are a number of proposed solutions which appear to be promising; however, all use a lubricant clean-up system of

Table V—Primary Coolant Pumps for Nuclear Reactors

Reactor Type	*Primary Coolant Pump Types*	*Lubricant Type*	
		Drive Motor	*Pump Bearings*
PWR	Canned motor centrifugal	Water cooled and lubricated	
BWR	Limited leakage centrifugal	Grease-oil*	Water†
OMR	Standard chemical process pumps	Grease-oil*	Lube oil, Grease or OM
GCR	Blowers	Grease-oil*	Lubricating oil
	Canned Compressors	Gas lubricated	
	Turbo-compressors	Turbine oils	
GCDR**	Turbo-compressors	Turbine oils	
LMR with Steam Gas, or Mercury Vapour Cycle	Sump type propeller pump‡ (external shielded motor)	Grease	Liquid metal
	Submerged centrifugal	Liquid metal	
Fast Breeder	Canned rotor pump electromagnetic	Liguid metal	
		N/A	
Aqueous Homogeneous	Canned rotor centrifugal	Water	

*Depends on speed and load, generally grease is used in sealed-for-life systems.
†Conventional lubes may be used with proper seal arrangements.
‡Motor located outside shielding for ease of maintenance, pump operates in liquid metal.
**Located outside shielding.

some form. The clean-up system as envisioned requires that the bulk of the coolant gas (helium in MGCR) be removed from the oil stream and no more than 2 lb/min of lubricating oil be retained in the primary coolant gas. In order to design such a system, several questions had to be answered. These were:—

(1) Solubility of helium (or other gas) in turbine oils at temperatures up to 200°F. and pressures near 600 lb/sq.in. gauge;

(2) Effect of dissolved gas and pressure on the lubricant viscosity;

(3) Foam and entrainment effects; and

(4) Vapour pressure of the lubricant and evaporation rate.

These four points have been investigated in detail in these laboratories and the detailed results will be published elsewhere. However, the experimental work indicates that for the first three items no serious problem exists with helium. The vapour pressure problem is not so easily solved, since the 2 lb/min lubricant contamination requirement limits the vapour pressure which can be tolerated in turbine oils for this application. Many turbine oils containing low-molecular-weight oxidation inhibitors will not meet this requirement, even though their base oil has the desired vapour pressure. In these systems, high-molecular-weight oxidation inhibitors will be required, and pre-stripping of light components may be necessary to meet the 2 lb/min requirement.

Limited information

This limiting concentration of lubricant permitted in the primary coolant again is based upon very limited information. The author has been unable to find any reference in the published literature to definitive experimental work aimed at establishing this requirement. The only available reference is some information obtained by Dr. A. Fraas (ORNL)[5] during a visit to Calder Hall which indicated that lubricant contamination in excess of 7 lb/min led to fouling of heat exchange surfaces, while at 4 lb/min no fouling was observed.

B. Control Rod Drives—A second moving part associated with the nuclear heat source is the control-rod drive mechanism. These mechanisms are required to move rods composed of fissionable, reflecting, or neutron-absorbing material to control the reactivity of the nuclear heat source. These rods must be positioned accurately, maintain predetermined fixed rates of motion, and must be capable of rapid motion in the event of safety shutdown. Thus, the ensurance of the continued operation of these drives is of major importance to both the safety and control of the nuclear heat source.

Three groups

The control rod drive mechanisms for stationary and surface propulsion systems include rack-and-pinion gears, lead screws, hydraulic or pneumatic systems, magnetic jacks, and winch-and-cable arrangements. Generally these mechanisms may be classed in three groups: (1) those which operated totally immersed in the primary coolant, (2) those which are only partially immersed, and (3) those which operate in gas.

The first category is exemplified by the Shippingport reactor where each control rod drive is moved by an electric motor, the armature of which is a rotor nut, through which a lead screw runs. The motion of the armature raises or lowers the control rod. The rotor nut, lead screw and support bearings for this unit are located inside a pressure tube attached to the reactor pressure vessel. The motor stator and position indicator are located outside the pressure tube. The armature is supported on ball bearings of stellite balls and races which are lubricated by the primary coolant fluid. Performance of these systems indicated 500,000 cycles of operation without excessive wear.

The second group typified by the control rod drives of the APPR, EBWR, ALPR and the *NS Savannah* uses a seal system to isolate the primary coolant from all or a portion of the drive mechanism. Primary coolant is used to lubricate only a part of the system; most of the lubrication requirements are handled by conventional lubricating greases and oils. For example, the primary coolant is used to lubricate the rack, pinion and rollers of the APPR design, while conventional greases and oils are required for the drive motors, bearings and gear box. In addition, some of these drives require hydraulic scramming when operating in a pressurized water system organic hydraulic fluids can also be used for this purpose, since the water and steel above the core provide adequate shielding.

Troublesome

The third group of systems, the "gas-immersed systems" are troublesome from a lubrication standpoint, since the lubricants are in contact with high-temperature gases (150°-200°C.). The principal lubricant requirements for this application are high-temperature stability and non-reactivity with the coolant. Radiation stability is not a problem. Greases are generally used in these systems and the major quality considerations are low oil-bleeding, good thermal stability, structure stability, and compatibility with reactor construction materials. When CO_2 is the coolant gas, conventional soap-thickened greases should not be used, since the soap structure is destroyed by reaction with CO_2. Non-soap-thickened greases are recommended for these applications.

There is a considerable spread of estimated dose rates for the control-rod drive mechanisms in the literature for the various reactors. This spread is due in part to the design differences. However, one additional point evident from the literature is that design dose rates in the region of operating parts are very rarely defined. Therefore, one must resort to estimating the dose rates based upon dose rates in adjacent areas. Table VI presents the maximum range of dose rates estimated from the literature and from discussions with design personnel.

Table VI—Estimated Maximum Dose Rates in Control Rod Drive Mechanisms* Rad/hr

PWR	$10–10^3$
BWR	10^2
OMR	$10^2–10^4$
GCR	? 0.1–10†

*Based on stationary power plants, and submersible and surface ship systems.
†Based on British gas-cooled experience.

Table VII—Estimated Dose Rates in the Control Rod Drives of Maritime Reactors—Rad/hr, Full Power

Pressurized Water (*NMS Savannah*)	10–20
Boiling water (22,000 s.h.p. tanker proposal)	0.250
Organic moderated (38,000 d.w.t. tanker proposal)	2.2×10^2
Gas cooled system (MGCR)	?

Considering the merchant ship proposals, the situation is very much better, since the dose rate data, even at this early design stage, is better defined. The only maritime reactor system where dose rate data were not available in the literature was the MGCR. Table VII summarizes the dose rate data for the maritime reactor proposals.

An examination of Tables VI and VII shows that the radiation dose rates are not excessive for these applications. At these dose rate, it would take 10-20 years before exceeding the 10^8 rads total dose tolerated by conventional lubricants.

C. Control and Stop Valves—Motor Auxiliaries—The control and stop valves and their motor auxilaries, which are located within the reactor containment, are exposed to a radiation flux which varies from 10-300 rads/hr. The type of valve selected and its actuation system depend entirely on the control required and the physical layout of the plant. These valves may use hydraulic, air, or electric actuation and may require sliding or rotating motion, etc. However, the primary coolant valves of maritime reactors generally are stop valves, and operate either full-open or full-closed, so that continuous throttling action is not required. The present submersible power plants utilize hydraulically operated valves which use water as the hydraulic fluid.

Early difficulty

Hydraulic-actuated valves have been adopted because of the early difficulty involved in incorporating air operated or electric motor driven valves in hermitically sealed systems which was required to meet the zero leakage requirement. These valves are lubricated by the primary coolant. Significant savings can be obtained in plant costs if electric or air operated valves of sufficient reliability and leak tightness can be developed. In the *NS Savannah* design, the primary coolant valves are electric motor driven, geared, limit-torque valves. These valves will be grease-lubricated and operate at an ambient temperature of 140°-150°F., in semi-sealed gear boxes, and must withstand transient temperatures up to 320°F. Conventional high-temperature greases should give satisfactory service in this application.

The motor auxiliaries and valve operators generally use grease-lubricated sealed-for-life bearings. With a 20-year service life expectancy for these motors (150 rad/hr at full reactor power) petroleum-based greases would just begin to show signs of observable radiation degradation at the end of this service life (10^7 rads). Therefore, it appears that conventional petroleum-based, soap-thickened greases will be satisfactory in this service.

D. Fuel Handling Equipment—The lubrication and design of fuel handling equipment depends upon the duty cycle imposed by the reactor's operating characteristics. For example, long periods between loadings of surface vessels allow handling systems to be portable with all other reactor considerations taking precedence. Such fuel-handling devices can operate slowly, have a relatively long setup time and can be moved manually with some mechanical assistance. Furthermore, it can utilize materials with a limited life span. This type of system needs to have a high degree of reliability during operation, but long periods between loads afford accessibility for maintenance. In this refuelling procedure, the reactor is shut down, a portion of the reactor pressure vessel is removed and the refuelling is conducted with water or auxiliary shielding present. The radiation dose rates in these systems are quite low—180 mr/hr to 4 rad/hr.—although higher dose rates exist in the shield-cask (up to 10^5 rad/hr.) Generally, the parts requiring lubrication do not see the higher dose rates. In addition, the components requiring lubrication (servo motors, hoists, gears and latching mechanisms) are available for relubrication. Conventional lubricants will again be more than adequate.

Different requirements

Short periods between loadings impose a different set of requirements. The handling system must be a permanent, integrated portion of the nuclear heat source. Loading and unloading must be efficient; manoeuvring must be fast and accurate. Long life is desirable but maintenance is possible. Within this group it is necessary to sub-divide this type into two categories: (1) intermittent refuelling with the reactor shut down and (2) continuous refuelling with the reactor at full power.

High for short periods

In the first category are reactors such as Shippingport, SRE, and Enrico Fermi reactor, where radiation dose rates may be high for short periods of time during fuel transfer, but relubrication is possible after use. Lubricants of enhanced radiation stability will not generally be required for this application because reliability during operation is the prime requisite of this equipment. Relubrication of parts exposed to high radiation stress with a low-cost conventional grease is a cheap price to pay for satisfactory operation. The second case which is typical of the U.K. gas-cooled systems and the Kaiser-ACF design, requires continuous rotation of fuel elements. The British designers feel that they require a lubricant which will withstand 10^9 rads total dose during a six month period in this application. The dose rates and total dose requirements of the U.S. air cooled reactor fuel system are not available in the literature at this writing.

Most of the previous discussion has centred around such reactor systems as the pressurized water, the boiling water, OMR and gas-cooled systems. The lubrication requirements of the newer reactor concepts (aqueous homogeneous, liquid-metal fuelled, fused fluoride, breeders, etc.) are somewhat speculative since only prototypes have been designed to date. Detailed information on surface propulsion systems based upon these reactors is non-existent. Therefore, the question of what direction future nuclear surface propulsion systems will take and what effect these designs options will have on lubricant requirements is difficult to answer.

However, the various options open to the designer can be discussed in a general way to see how lubricant requirements will be affected. The options open to the nuclear propulsion system designer include: (*a*) coolant type, (*b*) physical state of moderator and fuel, (*c*) distribution and location of fuel and (*d*) fuel cycle. A discussion of each of these options, and its effect on lubricant requirements would not be a fruitful

(*Continued on page 571*)

INSTITUTION OF NUCLEAR ENGINEERS

Owing to the space given to the Institution's Inaugural Dinner, the report of the September Council Meeting was held over. Both the September and October meetings are reported below.

MR. COOMBS submitted the final proof of the Articles and Memorandum of Association as approved by the Board of Trade. The design of the Certificate of Membership was also approved. The die-stamped certificate will be 10 in. × 8 in.

Dr. Paulsen reported on the Lecturing Guide and the Teaching Aids project, revealing that the response had been so striking that there was a large quantity of material in hand which would take much time and effort to collate. Broadly speaking, the United States and Germany had been the most helpful, but there had also been some very helpful suggestions from Britain, France and South America.

Dr. Paulsen said he had been invited, as a Council Member of the Institution, to stay at Karlsruhe, Germany, to participate in any course which may be running at the time and to act as observer. He hoped to accept the invitation in the summer and combine with it visits to Stuttgart, Basle, Winterthur and Geneva.

An offer had been received from Germany to start a library of coloured slides. The Ministry of Education had expressed a great interest in the work of the Institution and had offered to discuss the Institution's results at a later date. Dr. Paulsen felt this offer should be accepted, since the Institution may require assistance from the Ministry when, at some later date, it became an examining body.

The President expressed the Institution's appreciation of the valuable work Dr. Paulsen was carrying out and this was endorsed by all members of the Council.

At the October Council Meeting, the President was able to report the undoubted success of the Inaugural Dinner as reflected in the many letters of thanks and congratulations he had received from members and distinguished guests. The Council were of the unanimous opinion that the dinner had fully come up to expectations. In fact, the President thought it advisable to waste no time in planning ahead for the next Annual Dinner.

It was agreed that Mr. Jones should be given a list of members in his area with a view to forming the nucleus of a branch there.

It was decided to insert a notice in the press regarding the 100 guineas award and that the Secretary should prepare a circular to answer enquiries. It was decided that the Paper should be on industrial or medical lines. In this connection, it was agreed that rather than rush the award paper, the Council would accept Dr. Grassam's offer to deliver a short lecture at the forthcoming Annual General Meeting. It was agreed to ask Dr. Paulsen (who was absent from the meeting) whether he would care to present a short account of his work at the same meeting.

The President's Italian Medal

Gold medal awarded to Sir John M. Duncanson by the Rassegna Internazionale Elettronica e Nucleare

LECTURE BY DR. GRASSAM

"Nuclear Reactors in Universities"—subject of first Institution paper

THE first Institution paper will be delivered by Dr. N. S. Grassam on the subject of "Nuclear Reactors in Universities" at Caxton Hall on Friday, December 9th at 2.30 p.m. It will follow on after the Annual General Meeting and will last about 1 hr. Lantern slides will be used for illustration.

Dr. Grassam is a lecturer in mechanical engineering at Southampton University, where he is in charge of the nuclear programme. Under his guidance the university has made provision for the teaching of nuclear engineering to students taking the ordinary BSc(Eng) course. Special experimental and research facilities for those wishing to specialize in nuclear engineering on an Honours course are also provided. In addition, the university arranges extra-mural lecture courses in the subject.

Dr. Grassam joined Southampton in 1951 from the Royal Naval College, Greenwich where he was a lecturer. Before that he was with the Admiralty Gunnery Establishment, Teddington. A graduate of London University, he was trained as a structural engineer and in his early working life specialized in the study of stresses in concrete. He received his basic training in nuclear energy at the Harwell Reactor School.

N. S. Grassam, PhD, BSc(Eng)

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Radiation Safety and Control—V

KNOWLEDGE LIMITS RISKS—*says A. R. GOULD*

Royal Military College of Science

WHERE contamination inhalation and ingestion hazards are introduced a suitable counting room with appropriate shielding is usually required, in addition to the health-physics laboratory, together with maintenance and calibration facilities for nucleonic instruments. The exact outcome will depend on whether alpha, beta or gamma emitters are in use.

The actual handling facilities provided for operating with open sources will depend on whether there is any significant gamma radiation hazard which may require some type of remote handling or control gear in addition to shielding and viewing devices.

Personnel must be trained in the use of protective clothing and in particular in the methods of changing transfer of contamination on to the "clean" side of the barrier or on to "clean" clothes and of course without contamination of the skin. It must be understood that personnel should take nothing into the area as nothing which enters the active area may leave, except as active waste, or under a certificate of cleanliness from the health physics officer. Nevertheless, any personal items which remain in pockets and which are never exposed in the area may be excused if the contamination hazard is not of very high degree.

Adequate Overshoes

Visitors and staff only infrequently in the area, may wear overshoes and overalls which will protect the most common sites of contamination and for most areas have proved adequate to prevent the accumulated hazards that would exist if no clothing precautions were taken.

There must be no eating, smoking or drinking in the active area and no food or tobacco may be introduced into the area.

Personnel must acquire the habit before each operation to remember the hazards of active work and all the safety procedures. Probably the most important requirement for work with active material is a carefully thought out plan of action to reduce to a minimum the exposures involved. It must be recognized that more care must be taken all the time one works with active material and in planning what must be done, to allow a longer time than is normal with non-active materials. It is vitally important not to rush through an operation, neglecting obvious precautions. Some precautions may appear to be tedious but they are no more than one would have to accept in an explosives or toxic chemical factory.

Sufficient Time

Every action in the active area must be allowed sufficient time to be carried out with greater care than in an inactive area. For example, even the disposal of normal waste must be segregated into an appropriate "combustible" or "non-combustible" active waste bin, or "liquid" waste container. Some normally combustible plastics may not be deposited in the "combustible active" waste bin as they tend to melt and clog the fire bars of the incinerators. Dry waste must be carefully put in bins so that active dust is not disturbed; broken glass and metal objects with jagged edges or sharp corners must be wrapped to prevent puncture of the lining of the waste bins.

All personnel should be required to avoid areas of operations in which they are not directly concerned. Sensible use should be made of the extract ventilation systems which are designed to provide an airflow away from the operator. Operators should never stand between an operation and the air extract system.

Special investigations of radiation hazards should be made by the health physics staff when an operation is to be carried out for the first time. Whenever techniques are modified, new measurements of radiation hazard must be made by health physics staff and all methods of work should be designed to avoid unnecessary exposures. Even though an operation has been found "safe" by the health physics measurements, any slight change in procedure can introduce an avoidable risk.

The health physicist must also ensure that local codes of practice relate not only to every day routine handling of radioactive materials but also to their storage and transportation. He should also prepare suitable guides to action in the event of a major emergency together with the local fire officer and safety engineer.

In such a short survey it is inevitable that many relevant interests of the health physicist cannot be discussed adequately. The author is only too aware of omissions for example, in the field of radiological mathematics, unit of dose, and problems of shielding, statistics, solid geometry and particle physics that affect the calibration and standardization of nucleonic instruments. In the field of applied radiochemistry, the health physicist should be cognizant with current practice in waste collection, treatment and disposal; decontamination of personnel, equipment and buildings; the laundering of protective clothing and the formulation of protective barrier creams.

The more specialized fields of safety in criticality physics, reactor engineering and control, and radiation therapy are naturally beyond the scope of this short survey.

Increasing Variety

Increasing problems of safety are apparent as a greater variety of machine accelerators, ion generators, and reaction chambers comes into use. With the plethora of energetic photons and particles emitted by these machines in increasing variety there is often very little data to guide the health physicist with respect to radiation safety problems and each installation has its own specialized shielding requirements.

With pulsed machines operating in bursts of some 2μ sec 500 times each second, really high dose-rates can be detected, sometimes through many feet of concrete. It must then be realized that the milli-roentgen/hr scale of the more conventional integrating ionization chambers is really a roentgen/hr rate indicator, as the dose-rate is some thousand times that indicated. With the very scant data available from the field

of radiobiology and radiomedicine it is difficult to introduce realistic factors in the interpretation of permitted dose-rates and Mayneord has suggested[22] that a factor of three in interpretation of the dosage to personnel would be wise.

The ever growing number of multi-curie sources for industrial irradiation and food processing have their own safety problems[23] together with revival of the problems of ionized air (containing ozone and nitrogenous compounds) which appears to have been omitted from more recent ICRP recommendations. This will become a more urgent problem with kilo-curie sources and as the present day levels of ozone are restricted to below one part in 10^7 [24] it may require the replacement of air irradiated to only a few kilo-rads.

It will be apparent that the field of radiobiology and the associated one of radiomedicine are particularly valuable sources of essential data for the modern health physicist and the imperative need for even more data will lead to an increased tempo of research activity in these very young sciences.

Experience in Control

There now exists a wealth of experience in the control of the many difficulties and dangers associated with radioactive materials, which enables the limitation of risks. Techniques have been evolved for the realistic assessment of environmental hazards and it is now possible to achieve a greater degree of safety and protection (even with the increasing use of radio-active materials) as our understanding of radiation hygiene becomes more widespread.

The genetic and somatic risks from radiation work are now widely recognized and it has been suggested[25] that prospective employers have a moral obligation to bring these dangers to the attention of all newcomers contemplating a career involving radiation hazards. As this view may become generally accepted, industry should be able to emphasize the high degree of protection afforded by modern techniques together with the high level of safety already achieved by radiation hygiene. It is anticipated[26] that the industrial risks may be reduced to within the standards of accepted industrial practice and that we are not far off this goal.

In order to establish a firm basis for the assessment of the industrial hazards of atomic energy, refinements in our knowledge of radiation medicine are urgently required and it is becoming increasingly acknowledged that many unsolved problems challenge the radiation physicist and the radiobiologist.

With these limitations in mind it would seem prudent to avoid exposure to certain sections of the population at specific periods in development, especially the immature youth[27] and female workers[28].

This series of articles has attempted to introduce some aspects of radiation safety in general terms, for those not acquainted with the specific hazards of nuclear energy.

With the admirable safety record of U.K. government and AEA establishments and with the associated experience and technical "know-how," British industry is entering this field free from the encumbrance of out-moded plant. As it has only an academic interest in established practices, which have proved obsolete, it is presented with a splendid opportunity to achieve a high standard of industrial safety.

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Lubrication Requirements of N-powered Ships . . .

(*from page 567*)

approach, since no matter which option the designer takes, the ultimate result is the same—that is, the lubrication requirements would not be markedly altered, provided reactors are designed with today's ground rules.

Importance of Shielding

The major reason for the previous statement (that radiation resistance requirement will remain unchanged as long as present ground rules apply) is based primarily on shielding considerations. As long as manned surface propulsion systems have reactor compartments which are accessible 15 min after reactor shutdown, large amounts of shielding will be required. The most economical shield design is obtained when the bulk of the shielding required for equipment and personnel protection is placed as close to the reactor as possible.

Thus, it is apparent that a change in any or all of the present ground rules can markedly shift the lubricant requirements. This means reactor design concepts must be continually reviewed and examined to ensure the availability of proper lubricants for future reactor types as needs arise and the design ground rules shift.

Acknowledgement

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Maintaining Nuclear Cleanliness

Special Workshops at Erith

CERTAIN materials must be prevented from entering the gas circuit of a graphite-moderated gas-cooled reactor because they would have an adverse effect on the performance of the reactor, possibly preventing criticality being achieved. This means that plant designed for use in the gas circuit must not only be handled carefully during installation on site, but the same care must be exercised during all stages of manufacture. Special provisions have been made at the Erith Engineering Works of The General Electric Co., Ltd. of England, to comply with this latter requirement. They indicate the rigid manufacturing control necessary to apply what is termed " nuclear clean conditions " to all gas circuit plant. This control commences from the moment the parent metal enters the factory, and follows the component throughout its manufacture, culminating in a final cleaning, preserving and packing operation in a Nuclear Clean Workshop.

The prohibited materials can be roughly classified under one of three headings, namely neutron-absorbers, dusts capable of easily becoming highly radioactive, and materials which have an adverse effect of a metallurgical or chemical nature.

Impair Reactor Efficiency

The presence in the reactor core of a greater quantity of neutron-absorbing material than the designed amount would impair the reactor efficiency, and in the extreme case could prevent its operation. The danger lies not only in materials trapped in the core components themselves, but in dust which may be carried into the core by the coolant gas. In general, boron, cadmium and cobalt must not be allowed to enter the gas circuit at all (unless included by the designer) since they have high neutron-absorption characteristics. This is also true, but to a lesser degree, of chromium, manganese, platinum, rhodium, tungsten and vanadium, although manganese in carbon steel is acceptable since the quantity is usually insignificant.

Generally speaking all dust is capable of becoming radioactive. and then settling in parts of the plant subject to normal maintenance procedure, such as the steam-raising units. A further danger is that it can affect the operation of the burst cartridge detection equipment, by settling on or near the detectors and causing false operation of the system.

Avoid Accidental Accommodation

For these and other reasons aluminium, copper, molybdenum, nickel and selenium dusts, in addition to the dusts of the metals mentioned earlier, must be excluded from the gas circuit. The obvious solution to this difficulty is to remove all dust, scale, swarf, etc., from all items scheduled for this part of the plant, and to avoid accidental contamination by dusts during all stages of manufacture prior to installation. The removal is one function of the nuclear clean workshop and the associated process and preservation shop.

Certain metals react chemically with the fuel-element cans, in some cases forming undesirable alloys with the metal of the can. The four most important to be excluded from a reactor core are mercury, tin, bismuth and lead. Alloys and components of these and other metals must also be treated with suspicion, and prevented from coming into contact with " nuclear clean " plant.

In general, equipment needing to be nuclear clean can be classified into two categories. This classification is only rough, but, broadly speaking, those items of plant which are close to the fuel elements form Category 1, and those further away from the core and which therefore come in contact only with the coolant gas, comprise Category 2. There is, of course, overlapping between the two categories, but they provide the basis for a manufacturing procedure to be laid down for each item of plant requiring to be nuclear clean.

Plant falling into Category 1 has to be treated carefully from the start of manufacture until it is finally installed on site. This involves the correct choice of tools when machining and preserving the component during its passage round the factory.

Treatment of plant in Category 2 is not necessarily so critical in the early stages of manufacture. The nuclear clean process may commence with the entry of the component into the process and preservation shop.

Typical items falling into Category 1 are: fixed channel tubes; stainless steel tubes in the control-rod standpipes; garter restraints; control rods, their mechanisms and motors; channel-cooling circuits; thermocouples and fixing clips; television cameras; and the charge machine. Other components of the reactor and associated gas circuits can generally be considered to fall into Category 2 but nevertheless each component calls for individual assessment.

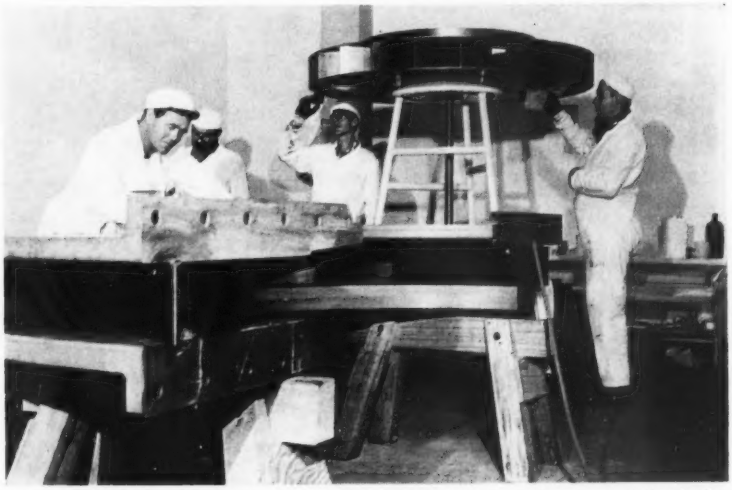
Extensive Modification

The nuclear clean workshop is part of the existing process and preservation shop, extensive modifications having been carried out to meet the new requirements. The major modifications included the partitioning of the building into two, thus separating the nuclear clean workshop from the process and preservation shop; the fitting of a false ceiling; the building of a reception bay with a sliding roof; and the provision of a room to serve as a personnel entrance from the outside to the clean-conditions area. Furthermore, the assembly area, reception bay and room for personnel entrance had to be pressurized to prevent foreign matter from entering while any door is open. In addition the ceiling, dividing partition, reception bay and part of the walls had to be lined with suitable material; the granolithic floor had to be sealed; and the exposed areas of the walls coated with metal-free paint. The dimensions of the nuclear clean

workshop are 85 ft 6 in. × 42 ft 6 in. × 30 ft high including the reception bay which is 25 ft square × 11 ft 3 in. high.

To enclose the roof space, prefabricated Girdalinc timber beams, at 4 ft centres, were used to bridge the 20 ft span between trusses. Timber connectors between adjacent beams formed a grid-like framework to which Laconite (melamine-surfaced hardboard) was fixed to form the false ceiling. With this method of construction it was a relatively simple matter to install fluorescent lighting flush to the ceiling and accommodate its control gear in the space above the false ceiling. Entrance to this space from outside the clean area is possible for maintenance of the control. A similar method of construction was used for providing a framework upon which to fasten the Laconite boarding for the dividing partition, and the reception bay. The vertical asbestos cladding which formed the upper portion of the original building was similarly faced.

General view of nuclear clean workshop, showing reception bay roof open and the crane about to lift a component into the assembly area



Impeller and half a diffuser of a gas circulator for Hunterston nuclear power station in the paint bay of the nuclear clean workshop. Hunterston is being built for the South of Scotland Electricity Board

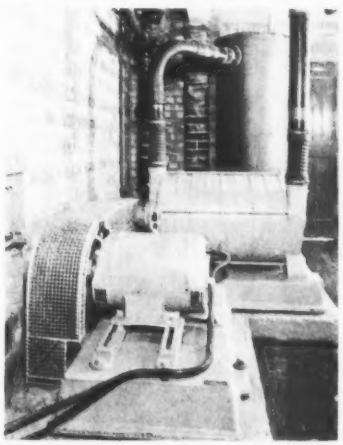
The floor of the original building was heavily coated with a lead-based paint. It was necessary to remove this completely by means of pneumatic fettling tools, and then to seal the floor with Sealocrete Special Sealer TP73C.

The specification for the special paint used on the exposed steelwork and brickwork was rigorous as indicated in Table 1.

The reception bay, although part of the nuclear clean workshop, is capable of being isolated from the assembly area to enable final cleaning and inspection to be carried out before items or materials pass into the assembly area. Entry to the reception bay from the outside is by means of a Potter Rax door 16 ft wide × 10 ft 6 in. high. In addition a further door is provided in the dividing partition which separates the reception bay from the process and preservation shop. Thus items treated in this shop can pass into the reception bay direct. Interlocks are fitted between the three doors and the sliding roof to prevent more than one being open at a time. The purpose of the sliding roof on the reception bay is to enable large pieces of plant to be lifted into and out of the bay as required by the 10-ton overhead travelling crane. A simple winch arrangement moves the roof, which is mounted on rollers, to give an opening 23 ft × 16 ft.

Other Features

In addition to the pressurizing, which is achieved with dust-free, temperature-controlled air, other special features in the nuclear clean workshop include cleaning and filtered compressed air services located at strategic points; facilities for preservative spraying; and the adoption of suitable surfaces on the interior of the building for easy cleaning. The plant necessary to provide these



The vacuum cleaning plant for the workshop. It includes a multi-stage horizontal turbo-exhauster with a dust separator in the rear

Table 1.—Paint Specification

Application	*Aggregate of Group 1 metals, per cent.*	*Aggregate of Group 2 metals, per cent.*	*Aggregate of Group 3 metals, per cent.*
Primer	Nil*	1.0	3.0
Undercoat and finishing	Nil*	0.1	1.0

Group 1 metals: Mercury, boron.
Group 2 metals: Barium, bismuth, cadmium, gallium, indium, lead, lithium, thallium, tin, zinc.
Group 3 metals: Aluminium, antimony, calcium, cerium, copper, nickel, praseodymium, silver, strontium.
*Nil in the case of boron means not more than 50 parts per million.

services has been located outside the workshop in a new annexe to the existing building. A small colossus-type crane to assist with assembly work, and fitters' benches of new clean wood are also provided in the workshop.

All personnel entering the workshop have to wear special protective clothing. This consists of a skull cap, boiler suit (with tapes instead of metal buttons), shoes and gloves. This clothing is stored inside the room which acts as the personnel entrance, and changing is performed in it. Dirty protective clothing is cleaned under special conditions to prevent it coming into contact with incompatible materials.

The ventilation and pressurizing plant consists of an air filter system capable of handling 35,000 cu.ft/min (including 5,000 cu.ft/min for preservative spray extraction), and an air heater capable of raising the same quantity of air from 30°F. to 70°F. when supplied with hot water at a mean temperature of 170°F. A three-way modulator valve to the air heater is controlled by a thermostat situated inside the duct in close proximity to the fan, and a strategically-placed room thermostat.

Air Heater

The air heater is fed by a calorifier with an output of 2.5m. B.t.u./hr under normal operating conditions. The distribution of the air inside the assembly area is by four Deflecto grilles, each 60 in. × 36 in., mounted in the gable end opposite the dividing partition. Two 24 in. × 10 in. grilles in the personnel entry room provide the pressurized filtered air for this area, and two 15 in. diameter Airmaster diffusers fitted above the Potter Rax door meet the needs of the reception bay.

Four Operators

The capacity of the vacuum cleaning plant is such that four operators can work simultaneously on the various cleaning duties at any of the seven points provided. Five of these points are located in the assembly area and two in the reception bay. The plant incorporates a horizontal, multi-stage turbo-exhauster driven by a 20 h.p. screen-protected, three-phase squirrel cage motor; a dust separator; a textile filter having an external, hand-operated shaking mechanism; and a removable dust-bin.

Compressed air at 100 lb/sq.in. is supplied to eight outlets from an existing source, the only modification required being the fitting of a ceramic filter in the incoming line. Four of these outlets are located in one corner of the assembly area, which is set apart for the spraying of components. This area is fitted with fume extraction facilities. Two more outlets are located in the assembly area itself, and two in the reception bay.

The cleaning and preserving consists of removing scale, rust, dust and grease, coating with Trilac and encasing the component in a polythene container. A bagged desiccant comprising activated alumina in pellet form, is placed inside the container prior to it being heat-sealed. The quantity is dependent on the estimated time of storage since the polythene container is slightly permeable.

Two Different Procedures

Except for the final vacuum cleaning and preservative spraying, all other cleaning processes are performed in the process and preservation shop adjacent to the nuclear clean workshop. Two different procedures are in general followed, depending on whether the item is a non-machined or machined part. If it is a non-machined part then, depending on its size, it is either shot-blasted or pickled in an inhibited 10 per cent. solution of hydrochloric acid. After this treatment it is immersed in phosphoric acid. The component is then delivered to the nuclear clean workshop for any assembly work necessary and for spraying with Trilac.

For a machined or bright part, a trichlorethylene vapour bath is followed by a wash in a similar fluid, and a 1-2 min dip in phosphoric acid. The component is then ready for final cleaning assembly, preservation and packing under nuclear clean conditions.

After being cleaned in the process and preservation shop the component is brought into the reception bay of the nuclear clean workshop, through the door between the two shops. It is then cleaned by any convenient means including vacuum cleaning, inspected and passed from the reception bay into the assembly area through either the door or the roof. If required it is then sprayed with Trilac in the small area adjacent to the reception bay set aside for this operation. The preserved parts are then assembled if necessary, checked and packed in sealed polythene bags as explained earlier. When the plant is finally sealed in its bag it is taken out of the building through the reception bay and stored under cover until needed on site.

A frequent vacuum cleaning of all floors, walls, and the crane, etc., in the nuclear clean workshop is carried out as a routine operation to keep the dust hazard to an absolute minimum.

Contractors

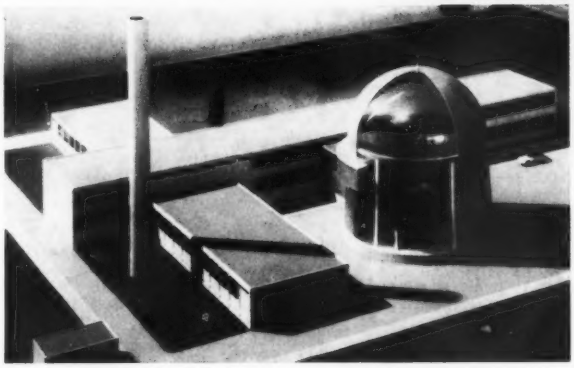
F. Ling & Co., Ltd. (building); J. Jeffreys & Co., Ltd. (ventilation plant); Sturtevant Engineering Co., Ltd. (vacuum cleaning plant); Atlas Preservative Co., Ltd. (paints); Sealocrete Products, Ltd. (floor sealer); Newsum, Sons & Co., Ltd. (timber beams); Laconite, Ltd. (melamine-faced hardboard).

$1m. Grant to University

THE U.S. National Science Foundation has made a grant of $1m. to the University of Pennsylvania for the purchase of a 12 MeV tandem accelerator for use in low energy nuclear physics research. For a number of years the University's facilities for research in physics have included a statitron, which is a low energy electrostatic generator, and a betatron, which is used to accelerate electrons and, indirectly, produced X-rays. The new ion accelerator will be an invaluable addition to these existing facilities and will enable the University to extend greatly its research programme in the field of nuclear physics, as well as the study of irradiation damage and of selective irradiation in the related areas of radio-biology and biophysics.

The Delft University Reactor

by
Iv. H. R. Kleijn



Model of the reactor hall, laboratory buildings and administrative block

(*Top*) **The reactor building under construction**

CONVERSION of the pool reactor shown at the *Het Atom* Exhibition, Amsterdam, in 1957, into a large-scale tool for university use is well in hand. The reactor, supplied by the AMF Industries, Inc., of America, originally had a maximum output of 10 kW; in its new shape the design output will be 1 MW, although initially it will be operated at only 100 kW.

The reactor is installed at Delft University and has been re-designed by the staff of the Reactor Instituut, an inter-university research organization established by the governing body of the Delft University. Assistance in this work has been given by engineering and architecture firms.

Design studies were largely completed and instruction started in 1959. The containment vessel has now been built and is undergoing gas-tightness tests.

The pool of the reactor will have two sections, the shape of which closely resembles that of the reactor at the Battelle Memorial Institute, Ohio. The sections can be separated by means of a push-button controlled watertight gate. The core is movable in the length as well as in the width of the pool, but will be operated in only three specific places; that is in front of a thermal column located in the smallest section, in front of a dry irradiation facility situated in the other square-shaped section and also in this section in front of three beamtubes.

The reactor will have six 6 in. ϕ and three 8 in. ϕ beamtubes and one 6 in. ϕ throughtube, a thermal column, a dry irradiation facility and a pneumatic rabbit system having a capacity of four. The reactor will be fuelled by more than 90 per cent. enriched uranium.

The present status of the reactor is that the experimental facilities are now being adjusted prior to the installation of the shuttering for the concrete pool walls (the bottom has been poured already). One section will have baryte concrete walls, density 3.5, the other will be made of ordinary concrete, although the density of this concrete will be increased up to 2.5. The concrete will be made according to an injection type method. The reactor located two miles from the centre of Delft will be housed in a gastight steel, dome type building, which has a diameter of approximately 80 ft and a height of 85 ft.

Three Entrances

The hall will have three entrances. Two via airlocks to be used when the reactor is in operation. The third is a large gastight door that may be opened only when the reactor is not working. Large experimental installations can be brought into the hall through this entrance. Also trucks can enter the reactor building using this facility.

Adjacent to the hall a laboratory building is under construction that will house research facilities for a chemistry, a nuclear physics, a reactor physics and a biology group. Further, an electronic and a small, universally equipped, mechanical workshop will serve the groups and room has been reserved for the administrative staff. Of this building, which has a crucifix shape, one-third of the concrete framework is ready.

When the reactor and the laboratories are in due time in full operation the small nuclear centre at Delft will take a moderate place among the nuclear organizations of the world.

H.M.S. Dreadnought

Britain's First Nuclear Submarine

The hull of the *Dreadnought* slides into the water at the Barrow shipyard of Vickers Ltd., after being launched by HM the Queen on the 155th anniversary of the Battle of Trafalgar

BRITAIN'S first nuclear-powered submarine, *HMS Dreadnought*, should be ready for operation by late 1962. The hull has been completed—it was launched by HM the Queen on Trafalgar Day in mid-October—and work is now going ahead on the internal fit-out. At the time of the launching the reactor plant was still in the States. When it is eventually shipped over it will be installed through holes cut in the hull.

Construction of the submarine started in February of last year. Five months later HRH Prince Philip, Duke of Edinburgh, laid the keel. The building schedule has been well kept despite the many problems and difficulties involved.

The *Dreadnought* has the largest submarine hull to be built in Britain. Because of this it was impossible to make use of existing facilities at the Barrow shipyard where it is being built and to save time it was decided to adapt these facilities as best as they could be instead of embarking upon more elaborate and time-consuming schemes which would have been better for the task in hand.

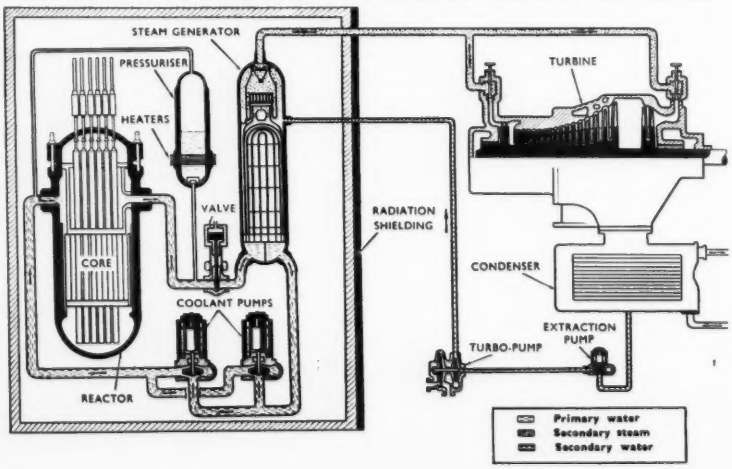
Another problem facing the staff of the shipyard was that the welding of the new alloy steel used in the hull had to be carried out without the advantages of prolonged tests or the training of personnel in the techniques involved.

When the idea of a Royal Navy nuclear submarine was first mooted it was planned that it would have a British designed and built reactor. In 1958, however, an agreement was concluded with the United States for the purchase of a complete propulsion plant as fitted in the *USS Skipjack*. As a result the submarine will be ready earlier than otherwise possible.

The plant is being supplied by the Westinghouse Electric Corporation and the submarine is being built for the Admiralty by Rolls Royce and Associates, Ltd., a group comprising Rolls Royce, Vickers and Foster Wheeler. Westinghouse are also supplying the group with design and manufacturing details of the reactor and Rolls Royce will be making replacement fuel for the reactor.

The Rolls Royce group will be responsible for the design and manufacture of the reactor for the Royal Navy's second nuclear submarine.

Flow diagram of the propulsion system heat generating system to be used in the submarine

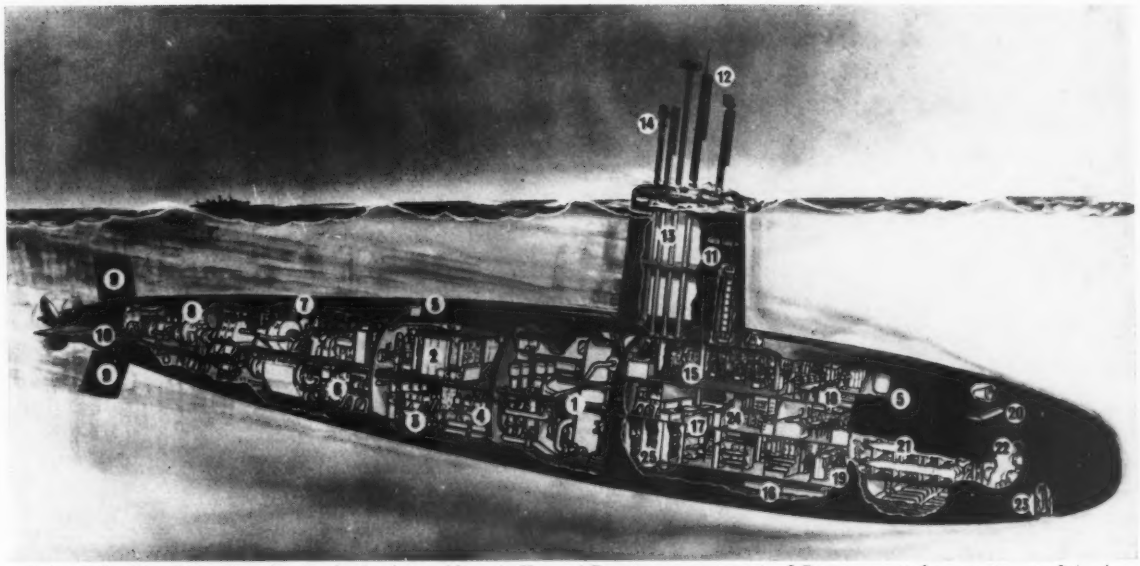


British Design

The *Dreadnought's* hull is of British design as regards both structural strength and hydrodynamic features, although the latter owe much to the pioneering work carried out by the U.S. Navy on *Skipjack* and *Albacore*. From about amidships aft the hull lines closely resemble those of the *Skipjack* class so as to accommodate the propulsion machinery. The forward end of the boat, however, is wholly British in concept.

Length of the hull is 266 ft and its beam 32 ft. Surface displacement is 3,500 tons.

The reactor will be a pressurized water unit, the fuel for which will be



Cutaway drawing of the submarine showing her internal layout. Key:—1 Reactor compartment; 2 Reactor control compartment; 3 Auxiliary machinery; 4 Diesel generator; 5 Escape hatch; 6 Main condenser; 7 Main turbines; 8 Electric propulsion motor; 9 Rudders; 10 Aft hydroplanes; 11 Surface navigating bridge; 12 Periscope; 13 Radar and radio aerials; 14 Snort; 15 Control room; 16 Electric batteries; 17 Crew's quarters; 18 Officers' quarters; 19 Electric space; 20 Forward hydroplane; 21 Torpedo space; 22 Torpedo tubes; 23 Stowed anchor; 24 Galley, and 25 Store rooms and refrigeration space.

uranium plates coated with zirconium. Water will be circulated between the plates to extract the heat produced by the nuclear fission process. This coolant (primary water in the diagram) is pumped to a steam generator of multi-tube form in which the heat in the primary water is transferred to the secondary water in the generator.

Steam Turbine Plant

The steam thus formed, which is initially saturated and not superheated, passes to a steam turbine plant which forms the main propulsion machinery, a proportion being used to drive a turbo-generator providing electricity for the plant and submarine services.

In order to achieve the high temperatures needed to raise steam for the turbines without steam forming within the reactor core it is necessary to maintain the coolant at a high pressure. This is achieved by the use of a pressurizer kept at a higher temperature than the rest of the circuit so that a steam bubble is produced in the upper half of the vessel acting as a buffer to prevent large changes in circuit pressure.

Reactor control is effected by plates of hafnium (a material which readily absorbs the neutrons evolved in the fission process) which may be inserted or withdrawn from the core. Moreover, an inherent control feature such that the reactor produces more power when the circuit temperature drops, due say to increased steam demand, but reduces power as the temperature rises, makes it an essentially safe system which is virtually self-controlled during all manoeuvring operations. Movement of the control rods is only necessary to compensate for the burn-up of the fuel and in case of an emergency shut-down of the reactor.

The reactor and its immediate ancillary systems are surrounded by shielding to keep radiation down to an acceptable level. Radiation arises principally from the reactor core and primary coolant and when the reactor is shut down the compartment may be freely entered. Moreover, since the steam for the turbines has no contact with the reactor core, the secondary circuit is accessible for maintenance at all times.

In Duplicate

Almost every electrical and mechanical part of the propulsion machinery is installed in duplicate so as to minimize the inconvenience of breakdowns. In addition, every control feature of the power plant and of the boat has been duplicated. These innovations will ensure an extremely high standard of reliability which, combined with the need to refuel at only very long intervals, will give her the ability to undertake patrols of particularly long endurance at continuous high underwater speeds.

Accommodation for her complement of 11 officers and 77 ratings will be of a standard which it has been impossible to attain in any previous submarine. The improved water distilling plant will for the first time provide unlimited fresh water for shower baths and for the washing machines in the fully equipped laundry. Separate mess spaces will be provided for senior and junior ratings, arranged on either side of a large galley, which is equipped for serving meals on the cafeteria system. Particular attention has been paid to the decoration and furnishings of the living quarters and to the recreational facilities which will include cinema equipment, an extensive library and tape recordings, all features which will help to offset the monotony associated with prolonged underwater voyages.

She will be fitted with an inertial navigation system and with means of measuring her depth below ice.

Her primary role is as a submarine hunter killer for which purpose she will be equipped with the latest developments in underwater weapons and detection.

Captain of the *Dreadnought* will be Commander Barnaby Samborne, RN, who has been serving in submarines since 1943.

N—Research in Italy work of the C.I.S.E

LIKE many an organization that has started in a small way and then expands at a rate faster than expected, CISE, the Italian nuclear research establishment, has for several years been housed in several buildings scattered in different parts of Milan. New premises have now been built, uniting all the laboratories and services into one centre. Called the "Centro Piero Ferrerio per Studi Sperimentali nel Campo dell'Energia," they were built by Edisonvolta in memory of the late Edison president, Eng. Piero Ferrerio.

CISE was founded in 1946 and for more than five years it was the only Italian centre engaged in nuclear activities. Legally constituted as a limited liability company, CISE is by statute a non-profit concern equally financed by two groups of private and public shareholders.

From 1952 to 1957 CISE was mainly engaged in technical assistance to CNRN, the Comitato Nazionale per le Recherche Nucleari. Since then research work, technical advice and designing have been undertaken for Euratom, ANIDEL and other bodies. Ever since its foundation CISE has supplied teaching staff for post-graduate courses at Milan's Polytechnica and itself trains technicians and research workers.

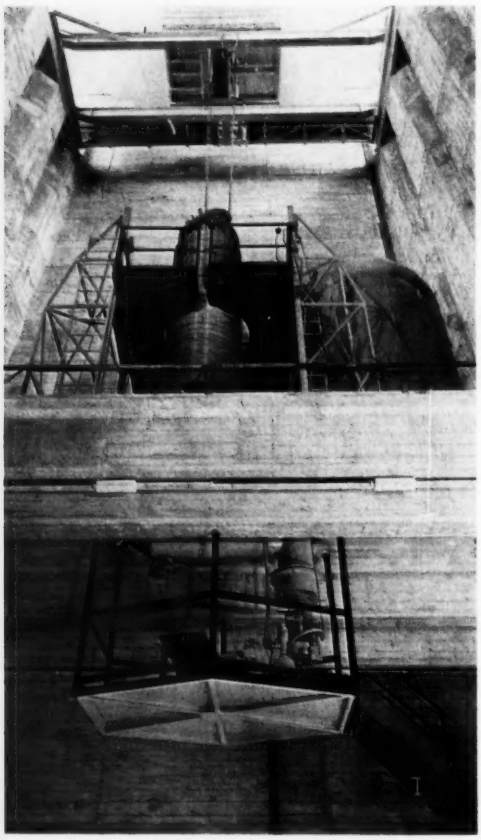
The technical organization of CISE comprises six laboratories—chemistry and radiochemistry, electronics, nuclear physics (with a health physics section), solid state physics, nuclear engineering, and technologies—and three auxiliary services—workshops, documentation and medical offices. Personnel totals 150.

The chemical laboratories carry out research in the field of radiochemistry and analytical chemistry and they consist of a radiochemical laboratory equipped for performing tracer investigations, a laboratory for analysing uranium and thorium compounds, and an analytical inorganic laboratory.

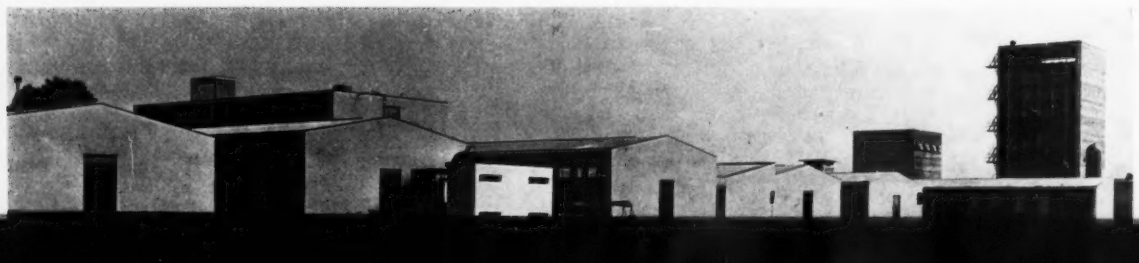
The purpose of the electronics laboratory is to design and construct electronic instruments not available commercially to be used in the other CISE laboratories. The main activities of the nuclear physics laboratory are the setting up of radiation detectors, counters, etc., construction and use of particle accelerators, cross-section measurements of several nuclear reactions and health physics measurements.

The preparation of high purity materials, crystal preparation by original methods, and diffusion experiments are among the activities of the solid state physics laboratory. Some of the work is carried out in close collaboration with French and American researchers.

There is also an international flavour about the work undertaken in the nuclear engineering laboratory where Euratom and IAEA scientists are to be found. Research is related to reactor design and operation. The technologies laboratory deals with fuel element manufacturing and processing.



(Left) *The 3 MeV Van de Graaf accelerator being assembled*



(Below) *General view of the laboratories. The Van de Graaf is housed in the tower seen on the right*

Encouraging the Spread of Nuclear Knowledge

A GLIMPSE AT U.S. METHODS IN SCHOOLS AND LAY EXHIBITIONS

by F. R. Paulsen, BSc, PhD, FRIC, MINucE

FILLING the world-wide gap in scientists and technologists means that the imagination of the young must be fired right now. If the rate of nuclear progress during the last two decades is to be maintained, it is the school-children of today who are to be shown the vital necessity of a strong band of experts to swell the ranks of those who are at present engaged in atomic research and industry.

In America the challenge is being met with determination and imagination. Inspiration and encouragement to those who will one day man the laboratories and power stations are spread over a wide range of age groups, from juniors to university students. The methods by which young scholars are persuaded of the great future and opportunity to be found within the nuclear field are designed to cover the general science background, the more specialized physics and chemistry of later years, and then the atomic world proper.

Perhaps one of the strongest forms of encouragement made to the schools is the Science Fair. So excellent is this idea, that a closer study of its purposes and operation is well worth while. Texas Panhandle Science Fair Handbook for Teachers, 1960, opened with the following explanatory words:

600,000 Exhibits

"Growing revival of emphasis on education in the sciences is one of the most encouraging trends in answering the challenge of preparing the young people of our nation to ensure their inheritance of our hard-won freedoms. One of the significant developments in this trend has been the introduction of the Science Fair. In 1950 only 13 area fairs were affiliated with the National Science Fair. In 1959 this number had grown to 168 fairs at which some four million people saw 600,000 exhibits made by students. The role of the teacher-sponsor in this development is inspirational. While we all realize that the Science Fair is no substitute for sound teaching, it is an exceedingly valuable supplement and a powerful stimulus, and has the additional advantage of increasing public understanding and appreciation of the role of science in life."

The typically American concept of a Science Fair is an idea aimed at encouraging the natural genius of the young and their desire to learn by activities both inside and outside the classroom. How does it operate? The mechanism involves a great deal of project work. Teachers are asked to make a list of possible projects which can be undertaken by students. To assist them in this task, the Science Clubs of America, in Washington, has published two booklets, entitled "The Sponsor's Handbook" and "Thousands of Science Projects." As examples of projects which have already been proposed, the following are drawn at random:—

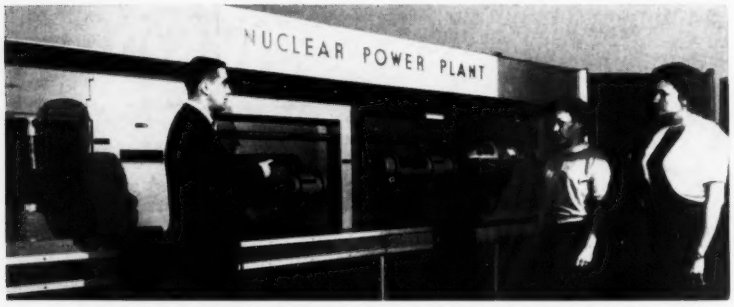
Primary, Grades 1-3, Group Exhibits: a.c. voltage generation, rocks of the U.S.A., water has energy because it has depth, sources of clothing, sea shells, how peas grow, spiders.

(*Above*) **A "walk-through" mobile exhibit presenting information on peacetime atomic energy, operated by the USAEC's Museum Division Oak Ridge**

Intermediate, Grades 4-6, individual or group exhibits: measuring ocean depths, a weather station, expansion and contraction of liquids, products of oil, the seasons, chlorophyll, weather and man, a cow's horns, rats are eating your food, how a tooth decays.

Junior, Grades 7-9, individual or group exhibits: a look into the future, building dams, crystal radio set, how lakes are formed, atoms, an arc furnace, glands in the body, flowers on stamps, mosquitoes, vegetable vitamins.

Senior, Grades 10-12, individual or group exhibits: ceramics, conductivity of liquids, hormones, products of wheat, snowflakes, five-carbon sugars in urine, uses of ammonia, fuels to jewels, Mendel's law, history of blood, winter trees.



A 23-ft model of a nuclear power plant, part of an AEC travelling exhibition

It is obvious that the scope of these project subjects is quite limitless, and titles are such that each gives almost unlimited play for the imagination and resourcefulness of the pupils, maybe assisted by teacher and parents.

Projects on Physical Sciences

Naturally, an idea of this type, born during the atomic era, is one which cannot fail to embrace topics within, or bordering on, nuclear science, especially in the work assigned to higher grades. If we take only the suggestions for the Senior section, grades 10-12, we find that the projects on physical sciences included the following: atomic radius effect on chemical activity, drawing of the uranium atom, ionization, U-235 under neutron bombardment, demonstration of the electric eye, uses of phototubes, explanation of an electron tube, the vacuum tube, uses of neon glow lamps, Wilson cloud chamber, high voltage mysteries, atomic fission and fusion, electron microscope, harnessing atomic power, ionization of air, the Geiger counter, function of a rectifier, tracing plant growth with irradiated materials, and mutations by irradiation.

Teachers are asked to enlist the aid of a librarian, and to work out a plan for use of the library by science students, and to have students instructed in the use of readers' aids, card indexes, periodical indexes, and the location and reading of current scientific publications. Each student has a personal interview with his teacher, at which a project is chosen related to his own interests, and an approach to local scientists for special help is made. The student is allowed ample project time, gives a progress report from time to time, and is encouraged to produce a smart exhibit. To this end, considerable assistance is given by such bodies as the Science Service, the Department of Agriculture, The Future Scientists of America Foundation, and the Oak Ridge Institution of Nuclear Studies.

As can be seen above, entries in the Texas Panhandle Science Fair (to quote a typical example), are in the Primary, Intermediate, Junior and Senior divisions, and may be either in physical or biological sciences. Further, the Junior and Senior divisions are subdivided into Boys and Girls. In the Primary division, only group exhibits are possible, while in the Senior division only individual exhibits will be accepted in the national fair. Primary entries must be capable of being mounted on the wall, on boards 22 in. × 28 in., while higher grade entries can be wall- or table-mounted. Official entry forms are allocated to a fair director in each school, and all exhibits have to be free from identification with respect to person, school or town. In the 12 classifications in the Science Fair, each first place winner receives a suitable trophy, judges using their discretion in the award of honourable mentions.

Two individual exhibitions, not necessarily first place winners, in the Senior division, are sent, with the teacher, to the National Science Fair which, in May 1960, was held in Indianapolis, Indiana. A tenth grade (sophomore) or eleventh grade (junior) student is selected to receive the Amarillo Rotary Club Award, which allows for payment of expenses up to $150 in attending the Junior Engineers and Scientists' Summer Institute, New Mexico State University, University Park, Albuquerque, New Mexico. Special prizes include the Grolier Award, the U.S. Navy Crusier Award, the Amarillo-Potter County Heart Association Award, the National Society of American Bacteriologists certificate of merit, and gifts of books from the New American Library of World Literature.

Nation-wide Appeal

The Science Fair, then, with its nation-wide appeal and organization, supported by colleges, Chambers of Commerce, businesses, industries and learned societies, offers opportunities for the scientific talent and provides recognition of this talent. It motivates, encourages, and inspires in students and teachers the desire for scientific experimentation, and discovery, encouraging talented youth to enter scientific careers, and focusing attention on science by acting as a stimulus to students, teachers and communities.

Passing from the more general sciences to the purely physical aspects, we may focus our attention on the activities of the Physical Science Study Committee. In order to administer the Secondary School Physics Programme of this committee and to assist other research and development projects in educational fields, Educational Services Incorporated, a non-profit organization, was formed under the auspices of the National Academy of Sciences and the Massachusetts Institute of Technology in September, 1958. The Committee itself was organized in 1956 at the M.I.T. to devise a modern course in physics for secondary schools and to prepare materials for such a course. Its membership includes university professors, high school teachers, industrial scientists

and technical specialists drawn from all over the country. The Committee's work has been sponsored by the National Science Foundation, The Ford Foundation, The Alfred P. Sloan Foundation, The Fund for the Advancement of Education, and other organizations.

The first stage of the project, completed early in 1957, was the design of a physics syllabus emphasizing the logical interconnections of the subject. Physics was treated as a product of experiment and theory, constructed by people with ingenuity, intuition, care and courage, a cultural force important to students with diverse interests and aspirations.

Learning Aids Developed

In the second phase, a set of learning aids was developed, including a textbook, laboratory apparatus and guides, films, examinations, and teachers' guides. The first versions were prepared in 1957 at the M.I.T., by 20 high school teachers and 25 university professors. The Educational Testing Service, of Princeton, New Jersey, worked with the Committee to develop achievement tests and a testing programme. To provide supplementary reading for students and general public, the Committee also initiated the Science Study Service of 100 paper-back books.

More than 30,000 students in 650 secondary schools studied the preliminary versions of the PSSC course over a period of three years, while over 1,000 high school teachers attended institutes concerned with the programme. With the support of the National Science Foundation, 50 summer and in-service institutes were convened for teachers interested in the PSSC course in 1958 and 1959. It was found that students handled the new course well.

The 270 schools in which PSSC materials were tested during the academic year 1958-59 received materials free of charge. Commercial suppliers working with the Committee handled most of the printing, manufacturing and distribution operations. Most PSSC materials were distributed at cost price during 1959-60 to 600 schools. In July, 1959, D. C. Heath & Co., of Boston, Mass., contracted with the Educational Services Incorporated to publish and distribute the textbook, laboratory guides and teachers' guides, publication to take place in 1960. Modern Talking Pictures, Inc., are likely to print and distribute PSSC films, and achievement tests will be available from Educational Testing Services, of Princeton, New Jersey. Doubleday & Co., and the Wesleyan University Press are marketing the first of the Science Study Series books under contracts dating from January and March, 1958. These books are not a formal part of the course, but are intended to teach science in an interesting way to students and laymen. The first nine titles received excellent reviews; 60 are in course of preparation, and many more are planned.

International agencies of the U.S. Government and groups such as the OEEC, the Pan-American Union, the Asia Foundation, the Ford Foundation, and others, are co-operating with the National Science Foundation with regard to use of PSSC course overseas. PSSC materials have been exhibited in foreign countries, and sections of the courses have been used in other lands, adapted to suit local requirements.

Mention has already been made of reading matter, the value of which should never be underestimated in any educational field. The *Scientific American* is one of the most popular scientific publications in the world, and its articles are highly valued for their authoritative and interesting character. It is appropriate, then, to mention here that in 1959, in response to increasing demand for materials from *Scientific American* for use in teaching, the publishers offered to teachers in the U.S.A. a selection of reprints of articles in physics and the biological sciences, and some 600,000 of these were ordered. This service was subsequently extended to the United Kingdom.

A " Flexible Textbook "

By means of these reprints it is possible for a teacher to compile, to suit his own course, a " flexible textbook." Reprints numbered 64 in biology, and 52 in physics, and many of these covered various aspects of nuclear science. Just to mention a few, there are articles on: What holds the Nucleus together, Mesonic Atoms, Elementary Particles, Bubble Chambers, The Nuclear Reactor, Radioactivity and Time, Pions, Neutrinos, the Overthrow of Parity, Fusion Power, Synthetic Elements, Radiation and Mutations, Radiation and Evolution, Radiation and the Cell. These reprints cost 1*s*. each.

We must next pass to more specific education in nuclear sciences. One of the foremost agents for this purpose is the American Museum of Atomic Energy, operated for the U.S. Atomic Energy Commission by the Museum Division of the Oak Ridge Institute of Nuclear Studies. The specific mission of the Museum Division is the dissemination of information through exhibits and correlated demonstrations or lecture programmes on the peacetime uses of atomic energy to students and the general public.

More Specific Education

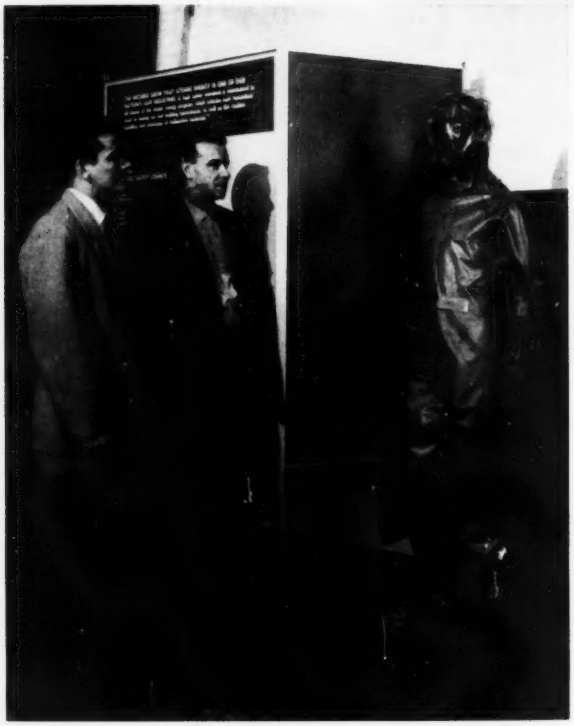
The American Museum of Atomic Energy was opened in March, 1949, since when it has operated continuously, making available to sponsors of various categories exhibitions on a rental basis. In 1956 the AEC changed its policy governing travelling exhibitions, and made exhibits available free of any charges, even of transport costs, to qualified local sponsors. At present, the 26 exhibits of this type are being presented throughout the U.S.A., including Alaska and Hawaii. These exhibition units are of four types. Firstly, the " This Atomic World " programme is presented principally in high schools. The " You and the Atom " exhibit is of the large, temporary form, suitable for exhibitions, fairs and large museums. " Atoms at Work " is shown in a mobile, walk-through van which has its own generator and air-conditioning unit. These three types of exhibit are sent out in charge of a museum representative, the exhibitions manager. The fourth type, or " package " exhibit, is sent out without personnel, transported by railway express or freight car, from sponsor to sponsor, on instructions supplied by the Extension Department of the Museum.

These exhibits can be assembled in a few hours by unskilled labour. The larger type " Atoms in Action " can be used by small museums, colleges and universities for public programmes, adult education and professional organizations. A smaller exhibit, " The Useful Atom," was specially designed and constructed for use in libraries. The Museum service operates the travelling exhibits programme, and it is visited by

about 100,000 people annually. Generally, the demonstration equipment and exhibits are designed by Museum Division staff, and constructed in the workshops at Oak Ridge.

The Museum, of course, has its own permanent exhibition, divided into seven areas. The first of these tells generally of the use of atomic energy; area 2 shows how isotopes are produced; area 3, how they are handled; area 4, how they are used industrially; area 5 shows agricultural uses; area 6 shows medical uses; finally, area 7, the Participation Room, allows visitors to see particle tracks, test their nuclear knowledge, hear about the U.S. reactor programme, find a radioactive turtle, and have a coin radioactivated, among other things.

Visitors to the Oak Ridge Museum are fascinated by the masterslave manipulators



Protective clothing as worn by atomic energy personnel, demonstrated in the Museum Division, Oak Ridge

Quite apart from the activities of its museum, Oak Ridge Institute of Nuclear Studies carries a formidable programme in many other fields. Through its Participation Programme, university members, 75 each year, spend 3 to 12 months in nuclear research at ORNL, ORINS, and the Agricultural Research Laboratory of the USAEC in Tennessee. There are also graduate fellowships, tenable at ORNL, and special fellowships in nuclear science and engineering awarded by the AEC, numbering about 150 each year, and tenable at 50 universities. There are special fellowships in health physics (including advanced training) at the rate of 70 per year, and industrial hygiene at the rate of about 10 per year.

Staff members of ORNL participate in a Travelling Lecture Programme, while through the Student Education Tour Programme, hundreds of students tour the Museum and other unclassified parts of ORNL. Two-week lecture courses are given through the medium of a 30 ft mobile laboratory, and in Oak Ridge and elsewhere, various symposia and conferences are organized. The University of Tennessee, through a subcontract with the Institute, conducts a Resident Graduate Programme, allowing Oak Ridge employees to continue formal education by evening and week-end school. The Special Training Division, formed in 1948, providing scientists with instruction in the techniques of safe and efficient use of isotopes, offers six-week sequences of two-week courses covering basic radiation physics, followed by special research or industrial techniques. There are also one- to four-week courses in medicine, biochemistry, radiation chemistry, radiography, veterinary radiological health, and similar specialized topics. Training in the use of isotopes is also offered to doctors who can spend 4 to 12 months in various residential courses offered by the Medical Division at Oak Ridge.

Long Tradition

The U.S.A., with its very long tradition of nuclear development, has by this time worked out a system of nuclear training second to none in the world. Yet every country has its own special requirements, and it would be foolhardy for any other country to try to copy blindly the example set by the U.S.A. Nevertheless, in Great Britain, there is still plenty which could be done along these lines, and some of the excellent ideas used in the U.S.A. could well be brought into operation here.

Problems of Radioactive Waste Disposal

REPORT ON RECENT CONGRESS IN MILAN

RADIOACTIVE waste disposal problems were fairly well covered at the congress on industrial water recently held in Milan, when several papers were presented on this subject by experts from Italy and other countries.

Two physicists from Agip Nucleare described in some detail the sources and means of dealing with the contamination of water arising from power stations of the Calder Hall type. Four of their colleagues in another paper discussed the experiments carried out on the decontamination processes involved.

Papers based on the experience of reactor operators came from the Julich Research Centre in Germany and the Institute of Physics, Milan, where a 50 kW research reactor is operated. In the field of measurement and control there was a paper describing a piece of apparatus designed to provide continuous monitoring and control of running water, and another which described the detection and measurement of radioactivity in effluents from nuclear plants as carried out at the Ispra Centre of Nuclear Studies.

In the paper on wastes from Calder Hall reactors the authors outlined the various sources of contamination which occurs in the spent fuel tanks. Exhausted fuel elements are stored in these tanks for a period of anything between 75 and 100 days to bring about a decay in activity and loss of heat before they are transported to a reprocessing plant. The principal sources of contamination in these tanks are fission products escaped from ruptured fuel cans and the products of the corrosion of the canning material.

Canned in Magnox

The fuel elements are canned in Magnox, a magnesium alloy which contains zinc as an impurity. Under irradiation the unstable isotope Zn-65 is produced. When the element is placed in the spent fuel tank this isotope is released into the water through the action of the corrosion of the Magnox. This corrosion is to some extent diminished by adding sodium hydroxide to the water, though this in turn can produce its own corrosion problems.

Also present in the water will be weakly radioactive quantities of corrosion products from the steel of the reactor pressure vessel and from the graphite.

Said the AGIP physicists, the calculations made on this subject and the experimental results obtained in England gave reason for optimism about the magnitude of the activity of this type and led it to be believed that the contaminated water could be discharged into the sea and rivers of importance without harm. At the same time they stressed that it would probably be advisable to provide the maximum safeguards in the way of water treatment plant.

Highly recommended

The most highly recommended type of water treatment plant was that based on ion-exchange and precipitation methods. The authors considered three cycles using these methods. They were:—

(*a*) Cation column in Na^+ cycle + anion column in OH^- cycle;

(*b*) Cation column in Na^+ cycle + acidification + degassing + anion column in OH^- cycle;

(*c*) Cation column in H^+ cycle + degassing.

The first two solutions would permit long cation cycles with a generous general reduction in the volume of very active regenerating agents. Because of the high *p*H of water, however, the efficiency of the anion column would be limited.

The third cycle seemed to the authors the simplest solution, even though it might have the disadvantage of a cation cycle limited to the cycle of sodium saturation and also it would require additional NaOH to maintain the appropriate *p*H value. Without a detailed economical analysis it would not be possible to say with certainty the best possible solution. However, the authors feel that probably the third cycle described would prove the most opportune. Eventually it could be used in conjunction with a mixed bed so as to attain a high degree of safety.

Radioactive pollution

Another paper presented at the congress dealt with the continuous and automatic control of radioactive pollution in water. Euratom regulations indicate that the maximum concentration admitted in water for Sr90 is 8.10^{-7} μC/cu.cm in case of people exposed professionally, and 8.10^{-8} μC/cu.cm in case of people living near nuclear installations. For any mixture of isotopes the admitted maximum concentrations become respectively 10^{-7} and 10^{-8} μC/cu.cm. Since in the water proceeding from nuclear reactors the most dangerous radioisotope is Sr90, the admitted limiting values of contamination are respectively 8.10^{-7} and 8.10^{-8} μC/cu.cm. An efficient control of contaminated water must be then made with a sensitivity of at least the same order of magnitude.

Simplest method

The simplest method for the measurement of radioactivity is constituted by the use of a Geiger counter immersed or located directly

on the surface of the liquid. The sensitivity of such measurement, however, does not exceed, in this case and under the best conditions, 10^{-5} μC/cu.cm. An improved sensitivity is attained by drawing off a sample of the liquid, evaporating it and then determining the radioactivity on the solid residue. This method, however, presents the inherent disadvantage of being discontinuous and so not immediately disposed to automatic control. Further, it requires the intervention of specialized technicians and the use of laboratory equipment.

The automatic apparatus described at the Congress, consisted of a pump which drew off water to be examined and then let it fall in dosed drops on a continuously moving paper strip. The strip would then be heated to evaporate the water and leave a concentration of radioactive waste. The paper then passes under a scintillation counter and the proportion of radioactive to known quantity of water calculated.

In an experiment with this apparatus, water was let fall in drops with a delivery of 0.24 litre/hr on a 10 cm wide strip of absorbent paper moving at 3 cm/hr. At this speed the distribution of water was maintained at the rate of 8 cu.cm/sq.cm.

The paper was then passed over an infra-red ray heating device and the ensuing concentration of the radioactive residue passed between two scintillation counters to detect, respectively, beta and alpha activity. The counters were connected to alarm circuits and recording apparatus.

Two alarms

Two alarms were connected up; one was to give warning of an increase of radioactivity beyond the preestablished limit, while the other revealed the complete absence of impulses and so suggested a failure of the apparatus. If the higher level is regulated on the basis of the value established by regulation for Sr90, in case of alarm signals, a chemical check of the contamination must be made to ascertain the presence of Sr90. Otherwise the admissible effective contamination is higher than that for which the alarm level had been established.

In case of very high contamination, it is necessary to take safeguards with extreme rapidity, and to this end the apparatus was completed by a Geiger Muller counter located in a water abducing tube which was attached to a warning alarm. This was set off when contamination values of the order of 10^{-5} μC/cu.cm were exceeded.

From the Institute of Physics, Milan, a paper was presented on the treatment of radioactive effluents at the local Centre of Nuclear Studies, which is installed with an homogeneous L54 solution, 50 kW reactor. The centre is located in a zone where the average density of population amounts to 20,000 inhabitants/sq.km.

Work limited

The Congress was told that up till then the Centre had not been faced with problems of radioactive effluents, since the Centre had limited its work to experiments of neutron physics. The data referred to in the paper had therefore been obtained on the basis of the experience of the radiochemistry laboratories already in service in the Institute and from calculations of the future programmes of the Centre. Data concerning the performance of the decontamination systems resulted from preliminary tests.

The normally non-active liquids proceeding from the radiochemical laboratories are collected in two tanks fabricated in AISI 316 steel and each volume of 1.3 cu.m and equipped with stirrer and level indicator. The activity of liquids in these tanks is measured firstly with a normal GM counter and then, in the case of a negative result, by examination of the dry residue of a sample, with a sensitive GM counter.

If the values of activity exceed those admitted in drinking water, the liquids are sent to the radioactive waste tank, located with the decontamination plant within a shielded cell of 33 cm thick concrete walls (density 3.6 gm/cu.cm). This AISI 316 tank, also of steel, has a capacity of 1.5 cu.m and is equipped with stirrer and level indicator. It receives non-volatile radioactive liquids from the radiochemical laboratories, laundry effluents and the core-washing solutions.

Composition will vary

It is foreseen that the composition of active liquids arising from the radiochemical laboratories will vary according to the realized experiments, but generally they will be made up of radionuclides with non-active organic solvents and suspended solids up to a maximum of 1 per cent. by weight. For these liquids it is calculated that the average activity will not exceed 1 c/ml and the maximum daily output will be of the order of 500 litres.

The radioactive volatile liquids will be made up mostly of organic substances and as their volume does not exceed the estimated 2-3 kg/month, they will not receive preliminary treatment. Instead they will be introduced into shielded vessels for final processing.

The washing of the core that will take place about every year, will lead to radioactive material being fed into the cooling water. The cooling circuit is located in a shielded zone and it is not thought that it will be necessary to get rid of normal cooling water due to a high level of activity. All the same, the water will be sent to the radioactive waste tank or decontaminated in an ion-exchange column.

Core-washing

Core-washing operations are destined to periodically eliminate the scale due to insoluble fission products in the combustible solution or, in case of repairs to the primary circuit of the reactor, to decontaminate the circuit followed by the combustible solution. The washing liquids are diluted solutions of HNO_3 and the calculated volume amounts to 500 litres. The activity present after washing is due to the combustible solution removed from the walls (about 10 ml) and the scale. According to calculations this activity should not exceed 10 curies immediately after the extraction from the reactor and should decrease to 1 curie or less after six months. Owing to this reason the core-washing solutions will be kept for about 200 days before the treatment in six AISI 316 steel tanks shielded by 30 cm of concrete (density 3.6 gm/cu.cm) and located in a cell shielded by 35 cm more of concrete of the same density.

The passage of the solutions from the reactor core to these tanks and successively to that for radioactive liquids will be realized without pumps by pressurizing or depressurizing operations.

Because of the Centre's location the maximum activity admitted in

drinking water is not to be exceeded in the elimination of liquid effluents: as a consequence a treatment plant presenting a factor of decontamination of at least 10^6-10^7 had to be realized. Owing to this reason and in relation also to the composition of the liquids to be treated, which would be complex and variable, it was decided to adopt a method of decontamination by evaporation.

The concentrator works by thermocompression and is of the coaxial-tube type; the evaporation of the liquid to be treated, maintained in natural circulation in the annular space between the coaxial tubes, takes place in a thin layer. The liquid to be evaporated moves in this space, circulating between the coaxial-tube heater or primary heat exchanger and the head of the evaporator, where the liquid leaves the steam to go back to the heater through a recirculation tube. The steam passes to the purifier, where it is freed from the conveyed particles, firstly by centrifugal action and then by filtration. After decontamination the steam is sent by a volumetric blower to the primary heat exchanger, where it gives up the evaporation heat. The sensible heat of the distillate and that of the concentrate, which can be discharged in a continuous or discontinuous manner, are given up in the coaxial-tube secondary heat exchanger. The initial heat for the starting of the evaporator is supplied by an electric boiler that is then regulated automatically to make up for the heat losses.

The distillate is collected in an AISI 316 steel vessel, from which is drawn a 3-litre sample to be analysed in the same way as the normally non-active liquids proceeding from the radiochemical laboratories; its discharge is subordinated to a $\beta+\gamma$ activity lesser than that admitted in drinking water.

Preliminary tests

Preliminary tests showed that the evaporator can concentrate the solutions to be treated up to 40 per cent. by weight of solid phase, and the distillate produced per kWh, in case of solutions with boiling point of 101°C. at 760 mm Hg, amounts to 26 kg, with an hourly output of 240 kg. The factor of decontamination is influenced by some parameters, among which is the boiling rate, expressed in kg of steam produced per hour and per sq.m of evaporating surface. For an output of 240 kg/hr of distillate (boiling rate 600 kg/sq.m/hr) the total decontamination factor exceeds 10^7.

The radioactive effluents destined to leave the Milanese Centre will be constituted by (*a*) the concentrated liquid phase proceeding from the evaporator; (*b*) the marked organic substances proceeding from the radiochemical laboratories; (*c*) the ashes proceeding from the incinerator; (*d*) the incombustible solid residues. They will be introduced, together with cement, baryte and other substances, into 100-l or 200-l containers. Several tests are being undertaken to determine the best mixture for occluding and shielding the radioactive substances. It is calculated that the 100-l and 200-l containers will be able to receive respectively a $b+g$ activity of about 0.15 and 0.35 curies without exceeding a dose of 10 mr/hr at a distance of 30 cm from their surface.

Four scientists from AGIP Nucleare described some experiments on the decontamination of radioactive liquid effluents in a closed cycle of water containing a mixture of fission and activation products and kept to a *p*H value of 11.5. In the AGIP laboratories the problem of Sr, Y and Zn removal by the calcium phosphate method and the problems of decontamination from Sr, Cs, Zn and mixtures of fission products by means of clay were examined.

The co-precipitation method of water decontamination using calcium phosphate, efficient for Sr89, Y91 and Zn65, did not give similarly serviceable results for decontamination from other radionuclides (in particular Cs137).

The use of ion-exchange resins has been studied by numerous experimenters and an ample documentation is available in the technical literature. This use, however, requires a periodical regeneration with the ensuing formation of other contaminating liquids or the elimination of a notably expensive material.

Cheap materials

The use of cheap and highly efficient materials was then considered advisable for economical reasons. Vermiculite and clay, it would appear, would satisfy such requisites, above all in the decontamination from Cs137. Their decontaminating power is attributed to absorption and exchange processes: according to some scientists, at low *p*H values the H^+ ions present in solution would arrange themselves around O atoms and OH^- radicals of clay, conferring upon it a positive charge; at high *p*H values, on the contrary, these centres would take a negative charge, and in this manner the material would attract the cations present in solution. The exchange process is attributed to a substitution of some elements constituting the clay, such as Al, Fe and Mg, by others in solution.

Good Results

The clay used in these experiments comprised a mixture of illite, chlorite, kaolinite and vermiculite. The results were good for the selective decontamination from single radionuclides. In the case of liquids containing a mixture of radioactive elements, however, they could only be considered as the base for further studies.

Experiments made on a mixture of Cs and Sr enabled the authors to affirm that the combined action of calcium phosphate and clay in the decontamination of water containing radionuclides presents the following advantages: (1) high efficiency with respect to the radioactive elements present in the water, taken from spent fuel element tanks; (2) little effect from *p*H values near that required (11.5) for reason of minimum corrosion of coverings; (3) simplicity of use; (4) possibility of reducing the radioactive residues to a compact and solid form by heat. The best results are attained by adding together coagulent and calcium phosphate to the clay suspension; in this manner it is possible to obtain a solid that subsides rapidly and an easily filtrable liquid.

Removal can be accepted

The methods of decontamination of radioactive liquid effluents by co-precipitation and by means of clay permit a removal that can be accepted in case of operations in closed cycle. If the water is to be directly discharged to the outside, a better decontamination may be required, such as that obtainable by evaporation, ion-exchange resins or electrolytic deionization.

Westminster talks about...

by Peter Lewis—Our Parliamentary Correspondent

OPPOSITION members returned to Westminster displaying the scar of political strife from their recent brouhaha at aptly named Scarborough. While the Labour Party has been an intrinsic part of Britain's political and social evolution, there are serious doubts on all sides about the compatibility of its present outlook with the contemporary scene. One day the British electorate will decide, as is their custom, that they want a change of government, but to what, it is difficult to foresee.

N-ship

Party strife or no, there is work to be done and members settled in quickly with a business-as-usual flourish. **Dame Irene Ward** (C., Tynemouth) pitched into the Minister of Transport and asked him if he had now selected the reactor for incorporation in the proposed experimental pilot nuclear-powered ship. Dame Irene reminded the Minister that three reactors had been under consideration since July. **Mr. Marples,** the Minister of Transport, replied that the complex task of evaluating the five tenders that had been received was proceeding as rapidly as possible, but would take some considerable time yet. The Minister went on to say that he was not in a position to make any decision until the evaluation of the tenders had been completed.

Dame Irene said that everyone had already been told how long the whole project would take to come to some conclusion and appealed to the Minister to give some idea now, especially in view of the fact that nearly every other country in the world was getting ahead with nuclear propulsion. Mr. Marples answered by saying that he considered Dame Irene's remarks about every other country getting ahead with the nuclear propulsion of ships, an overstatement. Mr. Marples pointed out that it was a technical committee which was sitting and was not composed entirely of Government officials. Serving on the committee were the Atomic Energy Authority, ship builders, ship owners and Lloyd's Register. Until that committee reported, the Minister indicated that he could do nothing.

The detection of nuclear explosions led to a question by **Mr. Bourne-Arton** (C., Darlington), who asked the Minister for Science what plans the Government had for seismic research by the United Kingdom, directed to improving methods of detection of such explosions. **Sir David Eccles,** the Minister of Education, speaking for the Minister for Science, said in a written reply that the Atomic Energy Authority was starting an immediate programme of seismic research which was estimated to cost about £350,000 over the next 12 months. The programme would include some chemical explosions but no nuclear explosions. The Minister went on to say that it would help the United Kingdom to make a worthwhile contribution to the seismic research programme which he hoped would be agreed on in the Geneva Conference on Nuclear Tests.

London Reactor

The proposed installation of a " Do-it-Yourself " nuclear reactor in the University of London, prompted **Mr. David Price** (C., Eastleigh) to ask the Minister of Power if a licence had been granted to install a reactor in Queen Mary College. **Mr. Richard Wood,** the Minister, replied that he had granted a licence. The Minister said that he had recently sought the advice of the Nuclear Safety Advisory Committee about installing low-powered research reactors in the range of 10 to 100 kW (thermal) on urban sites. The Committee had now advised the Minister that, so long as the site, housing, design and operation of the reactors fully satisfied certain basic conditions, they could be safely permitted in built-up areas. The Chief Inspector of Nuclear Installations had agreed with this and had informed Mr. Wood that the Queen Mary College satisfied the conditions. Consequently the Chief Inspector had approved the issue of a licence to the College for the installation of a 10 kW research reactor on a site in West Ham.

Hardly a week after Dame Irene Ward had pressed the Minister of Transport for a statement regarding nuclear propulsion for shipping, **Major Wall** (C., Haltemprice) joined forces with her. He also pressed for a statement, and asked the Minister when he expected a nuclear-powered British merchant ship to be launched. Mr. Marples had little to add to his reply earlier to Dame Irene, but went on to say that a nuclear-powered ship could be launched within two or three years of the placing of an order but it would be a further two years or more before such a ship would be in commission.

The Future

While matters of nuclear energy were much talked of in the first week or two of Parliament reassembling, it was nuclear energy's monster offspring, the nuclear weapon, that was the biggest talking point. The Loch, with its incongruous prefix of Holy, started many hares, most of which remain at large, but with at least one major atomic power station (Bradwell) coming into service in the near future, questions concerning the future programme of atomic research and application will keep the Ministries concerned well on their toes. The Queen's speech gave no indication of any major undertakings in nuclear research, but Her Majesty's announcement that the *Queen Mary* would be replaced by another Atlantic liner with financial assistance by the Government, poses once again the question of nuclear-propulsion, and we await Dame Irene's entry as the champion of the cause.

Book Reviews

Progress in Nuclear Energy Technology Engineering and Safety—Vol. II. Edited by C. M. Nicholls, R. Hurst and R. N. Lyon. Published by Pergamon Press, Ltd. Price £5 5*s*.

The student of reactor technology and indeed all technical and scientific personnel working in this broad field must at some time find the need to consult papers presented at the two Geneva Conferences where most of the unclassified work on the development of atomic energy has been presented. The difficulty experienced in consulting the actual papers is in first determining which are relevant to the particular problem or aspect of atomic energy in mind and secondly in collating the various data presented since there is necessarily considerable repetition in papers dealing with particular topics and written independently by different authors. The sheer volume of paper presented at the second Geneva Conference has clearly necessitated collection of the papers into a number of topics and their editing to present the most useful information in logical sequence, thus making it more readily accessible. When completed, the Conference will have been so summarized in 11 volumes, of which "Technology, Engineering and Safety" is volume No. 2. The editors of the book have selected papers that are in general review papers rather than original works to cover their subject in five chapters: Reactor Chemistry, Reactor Materials, Engineering Studies, and Engineering Aspects of Reactor Safety. Each of these chapters includes appropriate information on the main reactor systems that have been studied throughout the world. In the chapter on chemistry the U.K. readers will be primarily interested in the data presented on the reaction between graphite and carbon dioxide coolant which demonstrates that little operational trouble should be expected from the Calder Hall and first round civil stations but that more work is clearly required to establish the combinations of temperatures and fluxes that could limit the usefulness of graphite as a moderator in more advanced reactor systems. The remaining sections of the chapter deal with the development of other moderators and coolants for organic moderated reactors, water systems, liquid metal fuelled and molten fluoride reactors. They give a general idea of the problems in the chemistry field that would be exchanged for the graphite problem if the U.K. were to pursue the development of thermal reactor systems that do not utilize graphite as a moderator. The chapter on reactor materials deals primarily with constructional materials, namely steel, zirconium and its alloys, aluminium alloys and beryllium and the only results given for effects of irradiation on fuel elements are for those used in the materials testing reactor at Idaho Falls. Most of the chapter is quite rightly concerned with the effects of irradiation on steels and the mechanical properties and corrosion resistance, particularly to water, of zirconium and zirconium and aluminium alloys. The data on these items are comprehensive and are presented in convenient tables and graphs. A more comprehensive treatment of the metallurgical aspects of reactor materials is no doubt to be given in volume No. 3, entitled "Metallurgy and Fuels." The chapter on engineering experience and practice deals primarily with engineering problems associated with the handling of sodium and liquid fuels for homogeneous aqueous reactors and liquid metal fuel reactors and includes much useful data on corrosion problems. However, in using fluids of this type there is considerable "know-how" obtained by hard experience in the design of mechanical components required for test loops and reactors. More examples of detailed design features would be welcomed by the practical engineer engaged on this type of work. The papers on design of irradiation experiments and hot laboratory inspection facilities serve the useful purpose of outlining the novel problems associated with these types of engineering design. In the engineering studies chapter the mathematical treatment and philosophies of choice of fuel element heat transfer surface and steam cycles for gas-cooled reactors are well written from the aspect of presenting methods of mathematical treatment of these subjects although in practice this must be backed up by considerable experimental testing of the more complex forms of heat transfer surface that need to be considered in designing fuel elements. The paper on the possibilities of achieving high temperatures in a gas-cooled reactor is well worth reading to obtain a general appreciation of the problems to be encountered in development of a system of a similar nature to the Dragon Project at Winfrith Heath. The remainder of the chapter comprises a Russian paper on heat transfer in water moderated and cooled reactors and a paper from the Argonne Laboratories on natural circulation boiling water reactors which presents a considerable amount of experimental heat transfer data. The chapter on engineering aspects of reactor safety contains a very good philosophical paper from the Argonne Laboratories on reactor containment that deals with the various factors that must be considered in choice of design, illustrates representative types of containment systems and briefly refers to work done on these systems. Two papers describe designs for vapour containment considered in the U.S.A. and hydrodynamic problems resulting from a reactor explosion and other papers briefly cover shielding problems, detection of burst cartridges including a detailed account of the Calder Hall system, and experiments made on the release of fission products from molten fuels. The chapter is by no means comprehensive in coverage of reactor safety and, indeed, one could not expect it to be so since safety is such an integral part of any reactor design that detailed aspects such as behaviour under fault conditions cannot be covered adequately in a generalized treatment and must be closely associated with the design of each specific type of reactor system.

J. MOORE, MINucE.

UKAEA, Sellafield.

Role of Nuclear Propulsion in Merchant Shipping. (A Forum Report.) Edited by G. Edwin Brown, Jr., and William J. Smith. Published by Atomic Industrial Forum, Inc., New York. Size 10¾ in. × 8½ in. × 172 pp. Price $7½ (approximately £2 10*s*.).

Before nuclear powered merchant ships become a reality on any considerable scale, a vast amount of research and development will have to be completed, and this publication by the Atomic Industrial Forum certainly gives much food for thought to the technician who hopes to direct this form of energy to mercantile shipping. This publication is in the form of papers and discussions held in Philadelphia in April this year. It is therefore essentially an American effort, although it contains a useful summary of activities elsewhere than in the United States, including the United Kingdom, OEEC countries, and Japan. So much ground is covered in comparatively small compass that the reader is apt to be irritated by finding that he is just hoping to get his teeth into a subject when one paper ends and another begins. For example, Mr. David L. Gorman writes on "The Present Status of Nuclear Technology," starting off with reactor concepts. Then on the next page we come to "Application to Marine Propulsion" but after a page and a half is another paper, "Economic Goals for Nuclear Ships" by Mr. Harry Benford which has some 10 pages of "meat" followed by seven pages of interesting appendices. This summary treatment is typical of the publication, but the present rudimentary state of the subject perhaps makes that unavoidable. Papers and discussions deal with (1) economic potentials for nuclear merchant ships, (2) safety and liability problems, (3) propulsion systems, (4) plans of shipbuilders and operators, and (5) activities elsewhere than in the United States. As to the future of nuclear energy in general and the nuclear ship in particular, a remark by Mr. Francis K. McCune, president, the Atomic Industrial Forum, is worth noting. He recalls: "It has been said that an engineer is a man who fundamentally overestimates how much he is going to get done next year and terribly underestimates how much he *is going to get done in ten years*." When we consider that thousands of technicians throughout the world are now studying nuclear power, it would be wise not to underestimate the developments of the next decade.

D.S.W.

'NUCLEARIST' writes . . .

RADIOISOTOPES, which have so long been overshadowed by the glamour of nuclear power stations and atomic propelled ships, are coming into their own again, hand-in-hand with the application of radiations to industrial problems. The Isotope and Radiation Division, although the youngest section of the American Nuclear Society, is nevertheless the largest already. Under the chairmanship of John L. Kuranz, Vice-President of Nuclear Chicago Corporation, it has as its principal objective the fostering of research and development of radiations and their applications in industry, medicine and related fields. There is a powerful combination here—the ANS and NCC—which of the two will be the bigger gainer? My own guess is that Kuranz will see that the association is a profitable and happy one for both, with advantages to be gained on each side.

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Also high-lighting the importance of radiations over a wide field, is the new Pelican book, entitled *Isotopes*,* by J. L. Putman, of Harwell's Isotope Advisory Service. This is not by any means the largest or most expensive book available on the subject, but it is one of the best I have seen. It is often said that familiarity breeds contempt, yet Putman admits that he never ceases to feel surprised by the versatility of isotopes, these wonderful tools of science; he feels, too, that the intention of the book will be largely fulfilled if the reader can be moved to a sense of wonder also. This is a very healthy attitude for an author to adopt, and one that is all too rare. It means that he is not likely to "condescend" to tell his readers a story, but will approach them on an equal footing. The book contains a good series of photographs, but of particular value to the reader will be the 50 well-drawn and ingenious diagrams, adequate for ready comprehension, but not over-elaborate. The earlier chapters deal with radiations and their measurement, production of isotopes; there are chapters on the uses of isotopes in research work, factory, field, dating, agriculture and medicine, the uses of large radiation sources are dealt with, and the health aspects are analysed. This is a very useful book, which should find a wide readership.

*Penguin Books, Ltd.

While on the subject of publications, I should like to make mention of *Co-operation between Industry and Education*,† which contains a great deal of information on this highly important and controversial subject. In the first section we find details of the organization of courses, selection, welfare and discipline of workers on courses, technical teachers and refresher courses for these, and the provision of equipment and facilities by industry to colleges. This last point is, to my way of thinking, a vitally important one. The specialized courses required so often by industrial workers require equally specialized equipment, and unless this can be extensively used in other courses it may be difficult to justify purchase by the local education authority. Generous action on the part of industry can overcome this difficulty, even if apparatus is offered only on loan. The booklet gives many examples of co-operation between 40 industries and educational bodies, the former ranging from agriculture to wool. In the atomic energy industry, for example, the nuclear establishments have been able to provide the practical facilities within their own gates, within the limits of security, of course, as well as providing teachers. Much equipment has also been loaned by the industry to colleges. It is worth remarking, too, that the courses in nuclear energy sponsored by the City and Guilds of London Institute have been started at the request of the industry. While acknowledging the growth of co-operation between industry and education since the war, the booklet points out that there is still much more to be done to overcome the lack of understanding which often obtains in this field.

†Industrial Training Council.

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I would like to congratulate those at CERN upon the completion of their first year's publication of the *Courier*. Originally this fine little paper was a house organ intended only for members of the establishment, but within a single year it has found its way all over the world in English and French. Its contents have ranged from the sadness of losing colleagues to the pride and joy of achievement, such as the completion and testing of the great proton synchrotron. Incidentally, this latter machine has given some very interesting results. Its 25Gev protons, when allowed to impinge upon targets of light elements, have given rise not only to deuterium, as expected, but to tritons and the nuclei of helium-3. This has yet to be explained.

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The news of the development of the gas centrifuge in Germany produced misgivings among those who feared that this would facilitate the rearmament of the country with nuclear weapons. The gas centrifuge is now at a stage at which practical applicability is very likely, and the German Federal Republic, at the request of the U.S.A., has asked the German Patents Office to list the new device as a secret matter. As in so many other atomic matters, there is a very large political restraint being imposed. The Western Powers fear that countries of the Eastern bloc, which have not imposed any restrictions upon themselves, may be tempted to abuse the new process for military ends. This suspicion is certainly more nearly a conviction, and would also have been reciprocated had the development been made on the other side of the Iron Curtain. In the Paris Treaties of 1954 the Federal Republic agreed not to manufacture atomic, biological or chemical weapons, and accepted supervision by the International Agency for the Control of Armaments, which can inspect at any time the West German factories. The Federal Government has reaffirmed this policy in connection with the international reaction to the announcement that German scientists have developed an allegedly sensational and economical new process for the separation of U-235. The gas centrifuge, however, is not a German invention, and is the subject of extensive experimentation in many other countries. Neither has it been conclusively proved that it will render possible a process cheaper than the gas diffusion method which is at present used by all the members of the Atomic Club.

NUCLEAR NOTES

N-Power Station

OFFICIAL consent has been given to the building of a nuclear power station at Oldbury-on-Severn, 4½ miles downstream from the Berkeley station. Expected to be ready for operation by 1966 it will be the seventh nuclear power station to be operated by the Central Electricity Generating Board. It will have a design output of 550 MW and only short transmission lines will be needed to connect it to the existing 275,000v Supergrid near the Severn crossing. Application for permission to build a station at Oldbury was made to the Minister of Power in April, 1959. A public inquiry was ordered and this was held at Thornbury in April of this year. Preliminary work on the site, which covers about 180 acres, is starting almost immediately. The foundation conditions of the site are very good for supporting the weight of the heavy reactors of a nuclear power station. Three other sites were investigated on the Severn in Aust, Tidenham and Portskewett. Oldbury was chosen because it was the only site for which it was possible at the present time to devise a practical solution to the problem of abstracting and returning the large quantities of cooling water needed for a station of this size. The other sites all posed complex cooling water problems which require further lengthy investigations. These are continuing and in this connection a large model of the Severn Estuary has been constructed at the Hydraulics Research Station. At Oldbury advantage will be taken of a rock shelf offshore to create an artificial tidal reservoir of 350 acres which will impound water at high tide. From this reservoir the large quantities of water required for cooling the condensers of the steam turbines can be drawn during the low tide periods. This unusual arrangement will reduce the costs that would normally be incurred in obtaining cooling water from an estuary with as wide a tidal range as the Severn. Furthermore, the spoil arising from the construction of the reservoir will be suitable and sufficient to fill the site area level with the top of the river bank and thus provide a safeguard against flooding. During the construction of the station a peak labour force of over 2,000 men will be required. In this connection an undertaking has been given by the Generating Board to co-operate in making suitable transport arrangements to help any unemployed from the Forest of Dean area who wish to work on the site.

Russian Success

IT is reported from Russia that a group of scientists of the Joint Nuclear Research Institute at Dubna, near Moscow, have obtained xi minus hyperons by means of a powerful proton synchrotron. Headed by Wang Kang-chang of China, the group of specialists includes the Soviet scientists Mikhail Solovyev and Evgenia Kladnitskaya, the Chinese Ting Ta-chao, the Korean Kim Hi In, the Viet Namese Nguyen Din Ty, the Rumanian Alexander Mihul and others. They studied 102,000 photographs of traces of nuclear reactions and the results of the experiments were processed by means of an electronic computing machine. Xi minus hyperons—heavy, negatively-charged nuclear particles—are formed on the collision of high energy particles if at least one of them is a nucleon (a proton or a neutron). They were detected in cosmic radiation for the first time by British scientists eight years ago. Hitherto only 16 xi minus hyperons have been found in cosmic rays and only two particles have been produced artificially (in the United States in 1957). Scientists of the Joint Nuclear Research Institute have established with great precision the lifetime of the particle—about one-tenth of a thousand millionth of a second. They have also determined other important properties —mass, disintegration characteristics, and phenomena attending the birth of the particles. The documents on the success in obtaining xi minus hyperons are to be published.

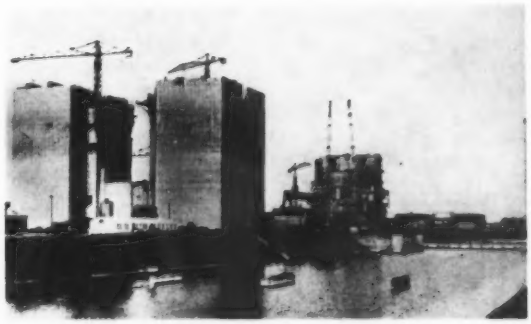
New Company

COMPAGNIE générale de télégraphie Sans Fil (CSF) and Société Intertechnique of Paris have just formed in association with Thompson Ramo Woodridge, Inc., of Los Angeles, a new company named Compagnie Europeenne d'Automatisme Electronique, with head office in Paris. The company will operate in six countries of the Common Market and will study, design and install electronic equipment for data processing and automation of industrial and scientific processes. Sales offices in Germany and in Italy will soon be opened.

Reactors for heat

THE frequency with which it is desirable from the safety point of view for different types of steam boilers to be examined is discussed in the report of the advisory committee on the Examination of Steam Boilers in Industry which is published as a White Paper. The Committee was set up in May, 1958, under the chairmanship of Mr. G. G. Honeyman, CBE, QC, to consider " the existing legal provisions relating to the examination of steam boilers in industry in the light of modern developments in design and construction, the size of units installed and the use of nuclear reactors as a source of heat, and to advise the Minister of Labour on any changes which appear desirable." Existing legislation contains detailed provisions governing aspects of the design, operation and examination of steam boilers, and requires that every such boiler on factory premises has to be thoroughly examined and certified by a competent person at least once every 14 months. During the war this period was extended in some cases to 18 months, and a limited number of relaxations have continued to be granted since. A further change in the law was made by the Factories Act, 1959, which gives the Minister of Labour power to make special regulations requiring examinations at such intervals and in such manner as he might specify. The main issue which, the Committee state in their report, they had to consider was whether in the light of modern developments in design, operating conditions and maintenance, any change in the period of 14 months appeared to be justified. Three members recommended that every boiler should be examined between eight and 14 months after being taken into use; that the period of subsequent examinations should be every 14 months after the first,

French Nuclear Power Station



The production of electricity from this nuclear power station in France is now near realisation, construction is taking place at Avoine near Chinon, in Touraine, Central France.

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except for water tube boilers with fusion welded or solid forged drums or headers with an evaporative capacity of 50,000 lb or more of steam an hour, when the period should be 26 months for the first 21 years of their operation after which it should be 14 months. Similar recommendations are made for a group of these types of boilers on a single site where the evaporative capacity of each boiler is 25,000 lb or more an hour or the total capacity of the group 100,000 lb/hr or more, and for waste heat boilers which are an integral part of a catalytic cracking plant or other large chemical or oil refinery processing plant. These members also recommend that any stationary steam boiler which has previously been used should be examined before it is taken into use in another factory. One member of the Committee disagreed with certain of these recommendations. He agreed that some boilers in the classes defined by his colleagues could with safety be subject to the extended period, but considered that no boiler owner should be allowed to adopt it in any particular case until the Factory Inspectorate had given their approval. He recommended that the period should either be 26 months subject to the approval of the chief inspector, or otherwise 14 months. The other members of the Committee saw no objection to these proposals on the grounds of safety but regarded them as unnecessarily elaborate and restrictive. They acknowledged that it might be held that the inherent safeguards offered by an owner's economic interest did not justify the assumption in any particular case that a boiler could be regarded as safe to run for 26 months between examinations. They did not agree that this difficulty would be overcome by requiring an examination by the inspectorate at a particular date. The Committee also recommend that for boilers associated with nuclear reactors there should be full consultation between the Ministry of Labour, the Ministry of Power and other interested bodies such as the United Kingdom Atomic Energy Authority before the issue of a licence for a nuclear installation. For those heat exchangers which could be isolated from the reactor vessel the first examination should be within 14 months and subsequently once every 26 months; for other heat exchangers the period and nature of the examination should be specified in the licence. A further recommendation by the Committee is that the "competent person" who would be required to carry out examinations of steam boilers should be an independent person, who has no personal interest in, and is not employed in or about the management of, the factory in which the boiler he examines is used.

Spectrometer order

A £50,000 order has been received by the Instrumentation Division of Associated Electrical Industries Ltd., from a London confirming house for two MS7 spark-source mass spectrometers for Russia. The spectrometers will be manufactured at the AEI Trafford Park Works and will be delivered to V/O Mashpriborintorg U.S.S.R. Orders for MS7 spectrometers have also been received by AEI from the U.S.A., Germany, France, Switzerland and in Britain from the National Physical Laboratory, the Services Electronic Research Laboratory and the UKAEA. The MS7 spectrometer was the first commercially-available spark-source instrument and was designed for the determination and analysis of impurities in inorganic solids such as metals, semi-conductors, graphite and many materials of interest to nuclear and electronic engineers. The sensitivity of the instrument is such that many elements can be detected at the level of 0.001 parts/m. (atomic), and in certain circumstances the sensitivity can be increased even further.

Heavy water reactor

THE boiling heavy water reactor of the Norwegian Institutt for Atomenergi at Halden, the first reactor of this type in the world and also the first water cooled power reactor outside the U.S.A. and the U.S.S.R, which is being operated as a joint undertaking of the OEEC European Nuclear Energy Agency recently achieved boiling for the first time. During this first boiling experiment the reactor power, which will ultimately be 20,000 kW was brought up to 2,000 kW. The reactor, moderated and cooled with heavy water, and using an initial fuel charge of natural uranium, first went critical in June, 1959. The first part of the experimental programme, comprising a series of low power tests to obtain information on reactor physics parameters, was finished last January. The reactor was then shut down for routine checks and modification work necessary before continuous power operation, and was brought critical again in August. The reactor was designed at the Netherlands-Norwegian Joint Establishment for Nuclear Energy Research, Kjeller, and was built by the Norwegian Institutt for Atomenergi. The main sub-contractors were the Kvaerner-Myhren, -Thune Combine (Mechanical Installations), the Chr. Michelsens Institutt (Control and Instrumentation), Høyer Ellefsen (Civil Engineering work), the U.K. Atomic Energy Authority (Fuel) and the U.S. Atomic Energy Commission (Heavy Water).

Symposium

ABOUT 140 scientists from 29 countries and representatives from Euratom and OEEC participated in the symposium on Pile Neutron Research in Physics recently organized by the International Atomic Energy Agency in Vienna. Since 1942, when the first fission reactor was put into operation, more than 150 atomic research reactors have been built or are under construction in some 30 countries. As a result much progress has been achieved in the development and broadening of the applications of reactors, and there are many pure and applied research programmes, where reactors are used. Among the various countries active in research programmes, there are some which already possess considerable experience in the building and operation of reactors and in carrying out reactor experiments, while others, who only recently started their activities in this field, lack such experience. Taking into account the variety of the research work which has been carried out and which can be done with a reactor, the developed techniques used in such work, and the varying possibilities in different countries and with different reactor types, it is evident that the newcomers in this field have to solve some difficult problems concerning how and what they can do with their new reactor research centres. The IAEA consequently decided to organize this symposium to provide for the exchange of information and experience in this field. The participants presented papers and exchanged views on various aspects of pile (reactor) neutron research in physics; pulsed reactors; special apparatus; nuclear physics research with pile neutrons; solid and liquid state physics research with pile neutrons. One session was devoted to discussing pile neutron research in physics in atomically less developed countries.

Accelerators

MORE than 325 scientists and engineers from 24 countries attended the three-day scientific conference on development and application of radiation-producing particle accelerators recently held in Amsterdam. Sponsored by High Voltage Engineering Corporation, of Burlington, U.S.A., and its subsidiary, High Voltage Engineering (Europa) NV, Amersfoort, The Netherlands, the conference included 22 papers on the design of particle accelerators and their applications in the fields of nuclear physics, particle research, radiation research and industrial processing. Several papers dealt with High Voltage Engineering's 10 MeV Tandem Van de Graaf accelerator, several of which are now in operation. Dr. H. Gove, of Atomic Energy of Canada, Ltd., discussed current experimentation being carried on with the Chalk River tandem. The new three-stage tandem was discussed by Dr. Peter Rose of High Voltage Engineers. With this machine, beam currents of 10 m. amps and energies as high as 30 MeV will be possible within ten years, he told the conference.

Tank type reactor

THE 5 MW (t) tank type reactor built for the Austrian Study Group for Atomic Energy by the American Machine and Foundry Co., recently went critical. It is installed in the £2m. research centre of the study group at Siebersdorf, near Vienna, and is adjacent to the recently constructed laboratories of the International Atomic Energy Agency, the staff of which will use it for various projects and experiments. The Austrian reactor is the tenth designed and built by AMF that has gone into operation throughout the world. The company has at present under design and construction a further 11 reactor projects both in the U.S.A. and overseas. The latest one to

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come into operation contains several interesting design features. One of those is the remotely-operated vehicle which enables direct access to be made to one face of the core for the purpose of carrying out large experiments. Another feature is that experimental equipment as well as the core are visible from the core level as well as from the top of the reactor.

American plant

GROUND was recently broken on the site of the 17 MW heavy water pressure tube reactor plant to be built by Westinghouse Electric Corporation for Carolina-Virginia Nuclear Power Associates Inc., at Parr, Carolina. The plant, which is scheduled for completion by mid-1962, will include engineering advances which will make it unique among American nuclear power stations. One of the principal features will be the elimination of the need of a large pressure vessel to contain the reactor core and which has been a basic and the largest component of previous pressurized water reactors. Instead the core will be diffused throughout a series of pressure tubes installed in a relatively simple and low pressure tank. As has been pointed out before, the larger a pressurized water reactor is, the cheaper is its production of power. The larger the plant, however, the greater are the problems involved in fabricating and transporting its pressure vessel. The use of pressure tubes, however, to a great extent alleviates these problems, Such tubes also make the inspection and replacement of fuel elements easier.

Graphite agreement

THE General Electric Co., of Britain has concluded a long term agreement with Nippon Denkyoku Kabushiki Kaisha (Nippon Electrode Co., Ltd.) covering the manufacture in Japan of special types of graphite developed by GEC laboratories for use in nuclear plant. Two types of graphite are involved—one of low permeability and the other substantially impermeable. The low-permeability material is produced by impregnating normal graphite with a form of sugar. Impermeable graphite involves a novel method for building up the carbon structure. It is likely that these materials could be used outside the nuclear field, for instance in the chemical industry. Under the terms of the agreement GEC will pass on to Nippon Denkyoku all information available on the processes and will assist the Japanese company to set up the necessary manufacturing plant. Nippon Denkyoku will be able to sell the two graphites made in Japan anywhere in the world with the exception of the U.K. A capital sum of £50,000 will be paid by the Japanese company to GEC under the terms of the agreement. In addition, GEC will receive royalties on all sales.

Remote control

BRITISH electronics and hydraulics experts have started work on a scheme to operate a machine shop by remote control. Operators watching TV screens in a control room some distance away will be able to carry out high precision machining operations by turning knobs on a small control panel. The work is being carried out under a contract awarded by a government department to Armstrong Whitworth Equipment, the Gloucester unit of Sir W. G. Armstrong Whitworth Aircraft Ltd., a member of the Hawker Siddley Group. The machines have to be remotely controlled because of unsuitable working conditions for the operators. If necessary, the control room can be several miles away from the machine shop. Although specially built for specific machining operations, the machines to be controlled are basically conventional precision tools. A similar scheme could easily be applied to standard workshop hydraulically-operated tools. The basis of the scheme will be the electro-hydraulic servo valve, developed by AWE as an industrial unit. This responsive device converts tiny electrical impulses into powerful hydraulic forces.

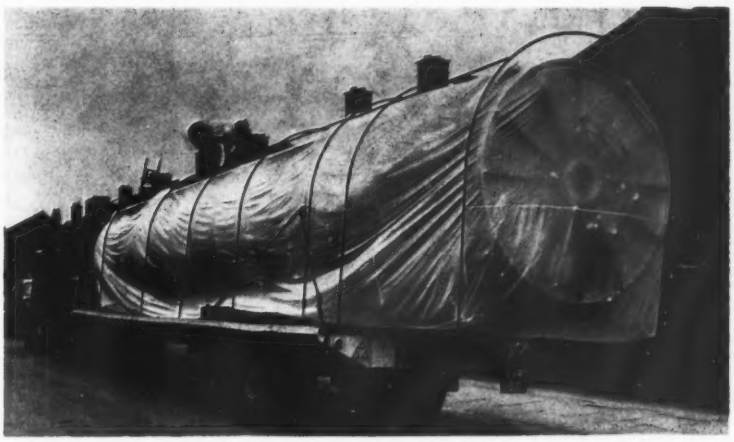
Translations

THE OEEC is to sponsor an international centre for translations from East European countries. The Centre will be housed at the technical library of Delft University and will: (*a*) establish a permanent connection between the national centres handling these translations and initiate joint studies; (*b*) keep an index of translations available and issue a regular bulletin of new additions; and (*c*) collect non-commercial translations from countries able and prepared to contribute them. In this connection the United States have promised to contribute their journals and special publications in this field. They will also send every year 18,000 abstracts, paper copies of translations in stock at the rate of 3,500 a year, and 8,000 microfilms. For the moment it is intended that the Centre should concentrate on scientific and technical material, with the prospect of adding new subjects once the work has got into its stride. The meeting of European experts proposed that the Centre should be set up for a short trial period, during which time it would rely on the help of the European Productivity Agency of the OEEC, with whom the idea originated. The delegates hoped that it would then continue as an independent unit, opening its doors to new members. Non-commercial translations collected by the Centre will be made available to the public for a nominal sum representing reproduction costs plus a small charge for overheads. This latter charge will contribute to the upkeep of the Centre.

Bradwell fuel

DELIVERY of fuel for the reactors in the Bradwell nuclear power station has started. The first reactor is scheduled to reach criticality about June of next year; the second later the same year. The uranium elements are stored in a specially pressurized, ventilated room.

On The Road

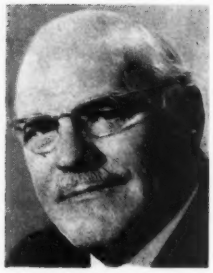


Final preparations in the transportation of the radiofrequency liner, a component of NIMROD, the giant proton synchroton (atom smasher) at present under construction at the new Rutherford High Energy Laboratory of the National Institute for Research in Nuclear Science at Harwell, Berkshire. The liner was manufactured by London Aluminium Company Limited and to prevent dust from entering the unit during its 2-day journey south, the liner was enveloped in Vybak (p.v.c.) film made by Bakelite Limited. The plastics packaging of the unit was done by the Coventry firm of Autoprufe Limited who used their own unique R.F. weld seal method for sealing the liner.

PEOPLE

Dr. Earl A. Long

Mr. F. S. Romanse



Sir John Duncanson

The chairman of the recently formed fourth board of governors of the International Atomic Energy Agency, **MR. ALLAN DOUGLAS McKNIGHT,** CBE, has been executive commissioner of the Australian Atomic Energy Commission since March, 1958. Previously he was Secretary to the Department of the Army. Educated at Sydney University and a graduate in law he was from 1945 to 1950 a legal officer in the Australian Attorney General's Department. From 1951 until 1955 when he joined the Army Department he was assistant secretary in the Prime Minister's Department. He has also been a lecturer in law at Canberra University College and a member of the council of that college. Mr. McKnight's vice-chairmen on the IAEA board of governors are **PROFESSOR G. NADJAKOV,** of Bulgaria, and **PROFESSOR C. GRAEV FERNANDEZ,** of Mexico.

MR. W. T. FLOWER, sales director of Bailey Meters & Controls Ltd., has been appointed deputy managing director.

DR. EARL A. LONG, an American authority on low-temperature physics, has joined General Atomic Division of General Dynamics as assistant director of the John Jay Hopkins Laboratory for Pure and Applied Science in San Diego. He goes to General Atomic from Chicago University, where he was director of the University's Institute for the Study of Metals and professor of chemistry. For several years he has been a Consultant at General Atomic on nuclear reactor core materials research and development. At Chicago University, which he joined in 1946, Dr. Long established and directed the largest academic low-temperature laboratory in the United States. During the war, he worked on the Manhattan Project at the SAM Laboratories of Columbia University and later at the Los Alamos Scientific Laboratory, where he was assistant director from 1945 to 1946. He has served as a consultant to the Atomic Energy Commission, the U.S. Air Force, and to the National Bureau of Standards Cryogenic Engineering Laboratory. Educated at Ohio State University, where he received the PhD degree in low temperature chemistry, he was a National Research Council Fellow, an instructor and then became a Lalor Foundation Fellow at the University of California. Later he was appointed professor of chemistry at the University of Missouri. General Atomic Division of General Dynamics is engaged in a variety of nuclear research and development activities including high temperature gas-cooled reactors for central station power, beryllium oxide-moderated gas-cooled reactors, applications of nuclear energy to space propulsion, TRIGA reactors for training, research and isotope production and medical applications, direct conversion systems, research in controlled thermonuclear reactions, and basic research in physics, chemistry, and metallurgy.

MR. F. STAN ROMANSE has been appointed division purchasing agent of the American Babcock & Wilcox Co., boiler division. He succeeds **MR. J. R. CONNELL** who is joining the Jessop Steel Co. Mr. Romanse will make his headquarters in Barberton and in his new position will be responsible for all purchasing activities affecting Babcock & Wilcox boiler manufacturing facilities throughout the United States. Born in San Antonio, Texas, in 1900, he has been with Babcock & Wilcox for more than 33 years. He joined the company in 1927 at the former Bayonne, N.J., Works. For the past 15 years he has been assistant purchasing agent of the boiler division with headquarters in New York.

SIR JOHN M. DUNCANSON, president of the Institution of Nuclear Engineers, has been awarded the gold medal, " Scientia et Divulgatio " presented by the Rassegna Internazionale Elettronica e Nucleare, to scientists and personalities who have shown particular merit in the field of nuclear energy. The medal has also been awarded to **DR. C. F. BAREFORD,** managing director of Vickers Research Ltd., **PROFESSOR H. LANGENDORFF,** director of the Radiological Institute, Freiburg University, Germany, and **PROFESSOR O. JOKLIK,** MINucE, of the Institute of Electronics, Electronics Studies Centre, Division of Atomic Physics and Nuclear Technology, Rome. The Rassegna Internazionale, which is to make the awards annually, is patronized by the Council of Ministers and the Comitato Nazionale delle Ricerche Nuclear (CNRN).

MR. DUDLEY SAWARD has resigned as managing director of Texas Instruments Ltd. He will remain on the board. His place as managing director has been taken by **MR. A. N. PROVOST.** Mr. Saward joined Texas Instruments on its formation in 1956 after spending 12 years in industry following a career in the Royal Air Force. In the RAF he was chief radar officer of Bomber Command and was associated with the development and introduction of radar and other electronic bombing aids. Mr. Provost, a former naval officer and a graduate of Tufts and New York Universities, was corporate manager of management engineering with Sylvania Electric Products. Later he was appointed chief engineer of Mergenthaler Linotype, and then joined the semiconductor-components division of Texas Instruments Inc., in Dallas, Texas, U.S.A., as chief industrial engineer. Subsequently he combined this duty with that of chief mechanization engineer, before being appointed manager of the special computer devices department in 1959.

The board of editors of the new journal *Nuclear Fusion*, to be published quarterly by the International Atomic Energy Agency, includes experts from 11 countries. They are **DR. K. W. ALLEN,** UKAEA, Aldermaston, **PROFESSOR L. BIERMANN,** Max-Planck-Institut for Physics, Munich; **DR. S. A. COLGATE,** Lawrence Radiation Laboratory, Livermore, California; **DR. W. F. GAUSTER,** Oak Ridge, U.S.A.; **PROFESSOR KOJI HUSIMI,** Osaka University, Japan; **DR. I. F. KVARTSKHAVA,** Institute of Physics and Engineering, Georgian SSR, U.S.S.R., **DR. BO LEHNERT,** The Royal Institute of Technology, Stockholm; **DR. J. G. LINHART,** Association Euratom-CNRN, Rome; **PROFESSOR ELÉMER NAGY,** Lóránd Eötvös University, Budapest; **DR. PAWEL J. NOWACKI,** Warsaw; **DR. V. D. SHAFRANOV** Kurchatov Atomic Energy Institute, Moscow; **PROFESSOR LYMAN SPITZOR,** Princeton University, U.S.A.; **DR. P. C. THONEMANN,** UKAEA, Harwell; **DR. J. L. TUCK,** Los Alamos Scientific Laboratory, U.S.A.; **DR. G. VONDRYES,** Commissariat à l'Energie Atomique, France; **DR. C. N. WATSON-MUNRO,** University of Sydney, Australia, and **DR. N. A. YAVLINSKY,** Kurchatov Atomic Energy Institute, Moscow. The Editor is **DR. J. G. BECKERLEY,** of the IAEA Staff, Vienna.

West Instrument Ltd., the temperature control instrument manufacturers, now have a full-time representative in France. He is **M. DE MICHEL** who took his degree as Ingénieur at the University of Paris. For two and a half years, M. Dé Michel worked in a research laboratory concerned with problems of intermittent frequency connected with radar. More recently, he has been engaged upon automation systems and the telegauging of oil storage.

Equipment and Materials

Items published in this monthly feature are compiled from manufacturers' current literature. Readers requiring further information should use the form at bottom of the page. Manufacturers are invited to send literature or details of their products for inclusion in this feature.

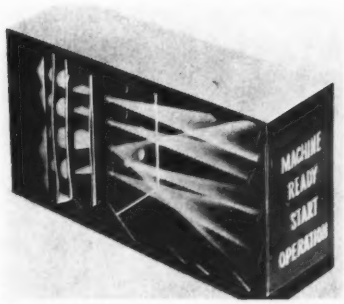
Multirange Meter

Taylor Electrical Instruments, Ltd., have announced the release of a new Multirange Meter, introduced to meet the demand for an inexpensive instrument with a high sensitivity of 20,000 o.p.v. but robust enough to withstand the hazards of everyday use. This instrument has a total of 21 self-contained ranges, current readings from 60 uA to 12 amps in six ranges, d.c. volts from .3v to 1,200v in seven ranges, a.c. volts from 12v to 1,200v in five ranges, and resistance from 0-20 megohms in three ranges, self-contained. The Model 105a has a clear 5 in. scale calibrated in three colours to facilitate reference of ranges, and its very reasonable price makes it one of the most competitive instruments in the world market. The instrument incorporates the new rugged centre pole movement resulting in extreme robustness and is assembled in a modern style rugged bakelite moulding. An alternative version incorporating an overload cut-out is also available. A high voltage adaptor for readings up to 30 kV and a high quality leather carrying case are also available at a very reasonable price. **(DEC 1)**

Taylor multirange meter

Digital Display Unit

Counting Instruments Ltd., have introduced a digital display unit which displays words backlighted with colour. It is possible to display words such as Machine Ready Start Operation, etc., or any other combination of words desired by the user. In addition, red, orange, yellow, green or blue colours may be displayed on the screen either by themselves or as background for the word messages. It is designed for visual communication and operations control with fully-automatic, semi-automatic, or manually operated equipment. It saves time, saves labour, and increases the efficiency of personnel and operations. The Series 80,000 digital display operates on a rear-projection principle. The unit contains a master condensing lens with 12 individual positions or lenses. On each lens is printed the desired word, message, or colour. When one of the 12 lamps at the rear of the unit is lighted, the lamp projects the corresponding word or colour on to the viewing screen at the front of the unit. The word message may be used by itself, or a coloured background light may be projected simultaneously to indicate the condition or situation. The unit features model construction and an aluminium case. It measures 3¼ in. wide, 5¼ in. high, and 12 in. long. It weighs 3¾ lb. The display is available in single units or in assemblies. **(DEC 2)**



Counting Instruments Ltd., have developed this digital display unit with backlighted display

Illuminator Magnifier

A bench illuminator magnifier has been developed by the Ellis Optical Co., which can be plugged into the nearest light socket. The "hood" of the "Ellisviewer," in which are housed two light bulbs, has an optically worked glass lens of 5 in. diameter and a magnification of 2½ times. It is not only adjustable on the main stand for height and correct focus, but may also be tilted to any angle, thus affording perfect vision angle and steady illumination of the spot to be examined. A press button switch is provided on the base plate and an ample length of well insulated and plastic covered cable is also supplied with each unit, the only addition required being a suitable plug. The main column and hood yoke are chromium plated and the base and hood are in a pleasing grey polychromatic finish, the large adjusting knobs being in black plastic. **(DEC 3)**

Cut along here

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Please send further details of the following items in the EQUIPMENT & MATERIALS *feature for December, 1960*

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....

IS THIS ENQUIRY CONFIDENTIAL? YES | NO

Enquirer's Name .....

Position .....

Firm .....

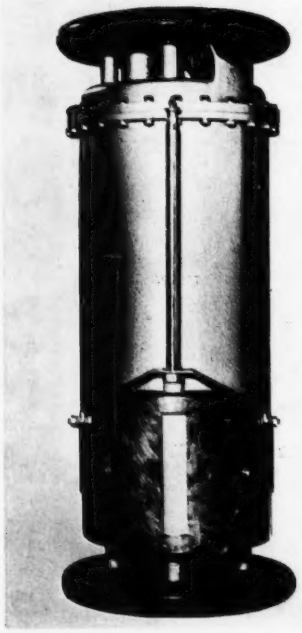
Address .....

The "Ellisviewer" bench illuminator magnifier

Portable X-ray Unit

A portable X-ray unit of 150 kV capacity and a weight of 51½ lb has been introduced by Pantak Ltd. Known as the Baltospot G150, it is available in two models—type D head, having a 60° field, and type P, with a 360° field. In both units the beam angle is 35° and the head is offset. The focal spot size of the tungsten target is 1.5 mm × 1.5 mm in the E150D whilst that for the G150P is 0.8 mm × 2.1 mm. A particular feature of the offset head is its use, especially in the panoramic version, in the examination of closed vessels of small diameter, the examination of a 3 ft diameter tubular vessel with a welded dished end being well within the capacity of the unit. Sulphur hexafluoride is used for both insulation and cooling of the X-ray tube, forced circulation cooling of the anode being effected by means of an internal blower. The tankhead is of drawn aluminium with bolted dished ends and amongst the numerous protection devices fitted are shock absorbent mountings for the tube in the tank head and further shock absorbment mountings for the tankhead in the cradle. A thermoswitch is fitted to guard against excessive temperature rises. The length of the tankhead is 1 ft 9 in. and the diameter is 8¼ in., the weight being 46 lb. The weight complete with end rings is 51½ lb, and the weight of the protective cradle is 6½ lb. The control unit operates from a 220v 50/60 cycle a.c. supply, using 6 amps, and accommodates mains fluctuations of 10 per cent. either way. Stepless type kilovoltage and tube current controls are incorporated, giving continuously variable control. **(DEC 4)**

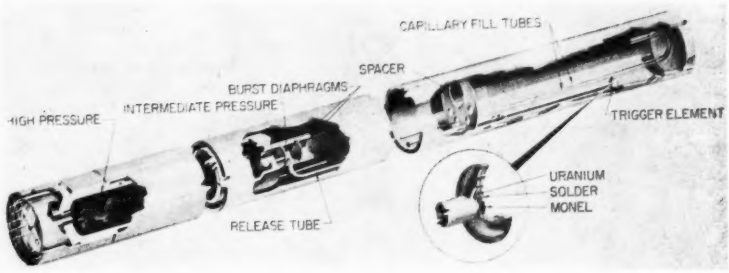
Portable X-ray unit introduced by Pantak Ltd



Reactor Safety Fuses

Nine nuclear reactor safety fuses have been built by Atomics International, a division of North American Aviation, Inc., for the U.S. Atomic Energy Commission. The fuses will be used in the maritime gas-cooled reactor critical experiment, operated by the General Atomic Division of General Dynamics Corporation, at San Diego, under contract with the Atomic Energy Commission. The fuses have been designed to automatically shut down research reactors without the use of external controls. While all reactors contain control systems to make them safe, use of a fuse is expected to provide additional protection in certain types of experimental reactors. The devices can be compared to electrical fuses in today's modern homes which shut off power when there is an overload. Fabrication of the fuses was done at the A1 laboratories. Completely self contained in a cylinder, a fuse is partly inserted in the core of a reactor where atomic fission takes place. The part outside the core contains boron trifluoride gas. In an operational device the gas would be released automatically into the other part of the cylinder in the event of a power surge. The gas would absorb neutrons required to maintain the chain reaction, bringing the reactor under control almost instantly and without damage. Atomics International began early work on a safety fuse in 1952 and has been developing the present concept for the AEC since 1957. Operational experience of the safety fuse concept will be gained as part of the experimental programme at General Atomic. **(DEC 5)**

Cutaway drawing of reactor safety fuse designed and built for the Atomics International Inc., a division of North Ameriean Aviation Inc., for the U.S. Atomic Energy Commission



Circular Lifting Magnets

The engineering group of The General Electric Co., Ltd., has recently extended its range of circular lifting magnets to include two new sizes, namely 30 in. and 80 in. diameter magnets. Full information of these two new sizes is included in the revised edition of Technical Description No. 379. In addition to standard circular lifting magnets GEC makes many other types including those suitable for salvaging steel and iron cargo from the holds of sunken ships; for handling hot ingots up to 650° C.; for lifting coils of steel strip; and for charging rotary furnaces with operating temperatures up to 1,000° C. **(DEC 6)**

Transistorized Capacitance Relay

Bailey Meters & Controls Ltd., include in their range of electronic instruments a transistorized capacitance relay. The instrument operates on the well established capacity method and is available in two versions, the direct mounting type has the probe integral with the relay and the wall mounting type has the probe separate from the relay but connected by a co-axial cable. The instrument housing of both types is weather-proofed and of aluminium alloy construction. Since adequate protection is given to the transistors and printed circuit the equipment is suitable for exposed applications. Several types of probe are available to fit into the standard casing to cover a wide range of applications. These probes can be easily interchanged if so desired. Both versions of the capacitance relay are constructed to withstand vibration. An electrical supply of 110-120v ot 200-240v a.c. single phase 50 cycles/sec is required to operate the unit. The power consumption excluding external alarm devices is approximately 3w. **(DEC 7)**

ISOTOPE WORLD

A Supplement devoted to the Subject of Radioisotopes

CHEMICAL EXTRACTION METHOD

Accurate Measurement of Sr90

A CHEMICAL extraction method which makes accurate measurement of strontium-90 in soil samples possible and may ultimately contribute to precise measurement of Sr90 distribution throughout the earth was reported by chemists of the Argonne National Laboratory, at a recent national meeting of the American Chemical Society in New York. The measurement of Sr90 is complicated because in soil samples or samples of vegetation, calcium is present, and calcium and Sr90 behave chemically in almost identical fashion.

The process described by the Argonne scientists makes it possible to separate strontium and calcium, thereby improving the accuracy with which the Sr90 content of samples can be determined. Even greater accuracy can be achieved in another way. Sr90 decays radioactively into yttrium-90 (Yt90). Using this extraction process it is possible to separate the Yt90 not only from the calcium but from non-radioactive natural strontium also present in such samples.

This method of analysis could be as much as 10,000 times more sensitive than other methods in certain cases. This process also has potential application to disposal of radioactive wastes. Present methods for disposing of fission products from spent reactor fuels result in a large volume of waste material which must be stored or buried at sea. Much of the volume is associated with the removal of Sr90.

Use of the Argonne extraction method could reduce considerably the volume of radioactive wastes which must be disposed of, thus simplifying the handling process and lowering the costs.

Two other potential uses of the process were described at the meeting. Sr90 can be isolated in pure form from spent nuclear fuel, thus making this important isotope available for research or industrial use.

The second application described was one about which it was said, "we hope it will not be needed." If, in the future, the amount of Sr90 falling from the atmosphere should require its removal from sources of food, the new technique could form the basis for a separation which would not at the same time remove the calcium which is a vital part of man's diet.

The new process reported in Mason's paper utilizes liquid to liquid extraction techniques involving acidic phosphate, phosphonate esters, and organic phosphonic acids as extractants.

New Processing Laboratory

THE Martin Co., of Baltimore, have developed a new processing laboratory designed to help produce one of the "man-made" elements in larger quantities than have ever been available before in the United States. The material, called Curium-242, can be used as a source of heat in small auxiliary power generators like the SNAP 1-A and SNAP-3 units built by Martin's Nuclear Division for the U.S. Atomic Energy Commission.

In the technical paper delivered at a recent national meeting of the American Chemical Society, a Martin scientist explained that crude supplies of the artificial element, americium would be purified and sealed in small aluminium capsules. These would then be shipped to an irradiation facility where the bombardment of neutrons inside a nuclear reactor would transform the americium into curium-242.

It was reported that Martin had also developed the process which will be used to remove the aluminium jacketing and prepare the curium for use as a power source, but that this final step would not be carried out in the company's Baltimore facilities.

It was said that curium-242 has several advantages over polonium-210, the fuel which was used in the first SNAP-3 generator when it was unveiled at the White House early last year. Curium-242 has a longer half life (163 days, compared to about 138 days for polonium); and the radiations from the former are somewhat more effective in generating heat. Curium also has a much higher melting point and promises to cost only a fraction as much to produce in quantity.

Like the polonium used in SNAP-3, curium-242 requires little shielding, so that it will be possible to handle freely the generators containing it.

The new Martin laboratory, it was stated, would use highly automated equipment and would be capable of purifying about a quarter of a pound of americium at a time. This, the author of the paper explained, would yield "about 1½ oz of curium-242—more than the total of all that has been produced so far, to the best of our knowledge."

Germany

BECAUSE of the increasing use of isotopes in continuous automatic production and quality control, the import of radiation sources into Germany has made a rapid increase over the last few years. They have in fact risen during 1957, 1958 and 1959 in the ratio of 1:2:5. All the same, compared with the rate of application in America, Germany is still only an infant in this field. More radioisotopes will, of course, be readily available as the various reactors planned for Germany come into operation. Some idea as to the profitable uses of radioisotopes in industry was given at the recent INTERKAMA (International Congress and Exhibition for Instrumentation and Automation) at Düsseldorf.

Tracer Methodology

A WIDE range of subjects was covered by the fourth annual symposium on advances in tracer methodology recently held in Chicago and sponsored by the New England Nuclear Corporation and Baird Atomic, Inc. John M. Reiner, of Emory University, and Henry Jeffay, of Illinois University, discussed the experimental design of turnover measurement studies in the unsteady state. Scientists from the Washington University Medical School described some experiences with labelling sugars, while Alvin Markovitz of Chicago University told of his experiences with labelling nucleotides. Several papers were presented on autoradiography and on advances made in the field of liquid scintillation counting techniques. Storage and manipulation of high specific activity tritiated estradol were covered by Elwood V. Jensen of Chicago.

Research Facilities

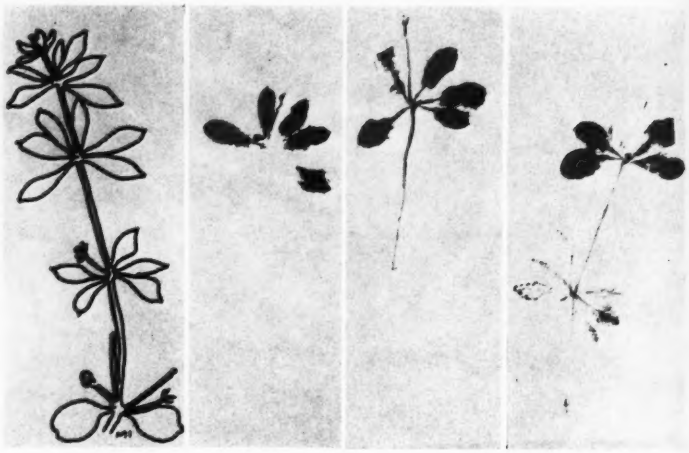
PENNSYLVANIA State University has approved an arrangement under which part of the University's nuclear research facilities at Quehanna, Pennsylvania, will be made available to The Martin Co., of Baltimore, for work in the development of isotopic power.

Martin has been a pioneer in the field, carrying out research and development on a variety of units in the SNAP units for the U.S. Atomic Energy Commission. In these devices, the heat generated spontaneously by small quantities of radioactive material is converted directly into continuous electrical power by banks of thermocouples.

At Quehanna, Martin will use five large, well-shielded "hot cells" in which the radioisotopes can be handled safely by means of mechanical manipulators prior to being sealed inside the fuel blocks and loaded into test generators. The cells vary from 12 to 15 ft in height and total more than 300 sq.ft in area.

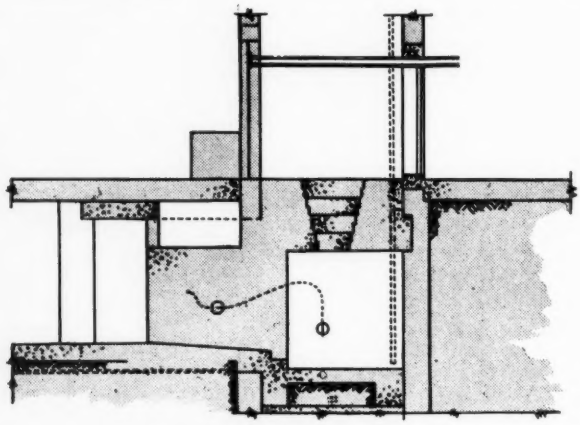
Research on Pharmaceuticals

The Boots Pure Drug Co., Ltd., familiarly known as Boots the Chemists, make an enormous range of preparations for use not only in medicine but also in veterinary science, agriculture and horticulture. To meet the ever increasing demands of these fields it is necessary to carry out considerable research and development work. Boots in fact spent last year £600,000 on research and employ some 400 people in this sphere alone. Among the many tools used by the researchers are radioisotopes and several experiments have successfully been carried out with them. Some idea as to the nature of this work is given in this brief article.



Progressive stages in the penetration and movement of two herbicides of similar chemical structure. On the far left is an outline drawing of a treated plant. From the left, radioautographs 4 hrs., 1 day and 2 days after treatment.

FOR some time now, the Boots Pure Drug Co., Ltd., have been using radioisotopes for their own scientific research, and they have been pursuing two main lines of investigation—one using small quantities of radioactive material for tracing purposes, the other using relatively intense gamma radiation from a cobalt-60 source.



Sectional view of the irradiation unit

Tracer techniques have already been successfully applied to a number of Boots research problems. Penetration of Ethidium into the cerebrospinal fluid of animals has been studied to see if the drug can attack trypanosomiasis at that level; if so, it could be of use in the human disease as well as the cattle disease, both of which are carried by the tsetse fly.

At the Thurgarton research station, labelled blood has been used to measure the blood volume of sheep, and to study the part played by potential blood-sucking worms in causing anaemia in sheep.

Measurements of the retention of Chlorparacide in the animal body were essential before permission could be gained for its sale as a spray for fruit trees in the United States.

Entamide, the Boots drug for amoebic dysentery, has also been studied. Although it had proved to be highly active and promising in the preliminary rat-screening test at West Bridgford, it did not fulfil its promise in acute clinical cases. Radioactive studies have shown that, though relatively insoluble in water, it is quickly absorbed and excreted in the urine and so may not reach the amoebae in the gut in any great concentration.

At the moment, close attention is being paid to the problem of how selective weedkillers such as Cornox and Iso-Cornox operate. These studies could indicate new lines of approach for finding new and more efficient weedkillers.

Assays of antibiotics in a brew containing a mixture of antibiotics and investigations of the build-up of the penicillin molecule from such starting points as methionine are also being carried out.

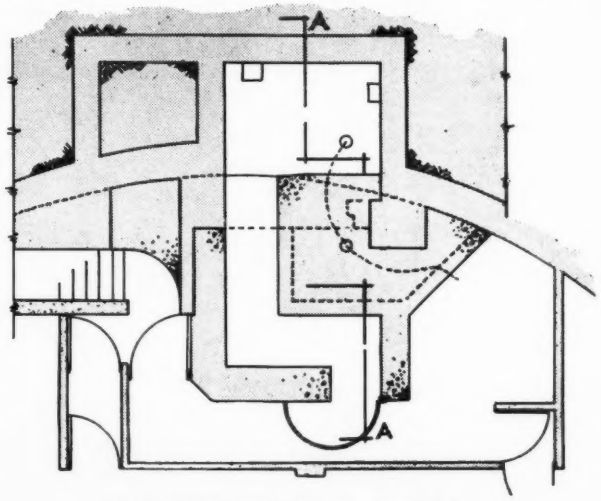
The scope for further applications of radioactive tracing is immense. It can show up the sequence of events in complex chemical reactions. On a larger scale, it may clarify the reasons behind different production yields and explain the formation of unexpected by-products. It promises to be a very neat way of checking the dispersion of small quantities of materials added to large mixtures, as in animal food supplements; this technique is already widely used by manufacturers of cement, chocolate, glass, gramophone records and other odd mixtures.

Research with gamma radiation is being carried out in a specially-constructed unit in the basement of a building at the company's premises in Nottingham, where walls of concrete 4 ft thick are a permanent shield against the high-intensity radiation.

In this unit several investigations are being made. Gamma radiation may prove to be a convenient way of sterilizing finished products in their containers, making it possible to dispense with extensive sterilization precautions throughout earlier stages of manufacture.

Its effect is also being studied on biological materials and biochemical products such as heparin and antibiotics, with a view to raising their safety level and generally improving their properties.

It is hoped that gamma radiation can be used to initiate chemical reactions which will not proceed under normal laboratory conditions, and here the possible horizon is very wide. The importance of fresh developments in this field for a company concerned with producing useful new chemical compounds for application to medicine, veterinary science, horticulture, agriculture and elsewhere is obviously very great.



Plan of Boots irradiation cell at Nottingham

W.M.O. and Nuclear Energy

ROLE OF THE WORLD METEOROLOGICAL OFFICE

ONE of the purposes of the World Meteorological Organization laid down in its convention is to encourage research and training in meteorology and to assist in co-ordinating the international aspects of such research and training. At first sight, the connection between meteorology and atomic energy for either research or training purposes may appear vague and ill-defined but, in reality, there is a broad common field and each discipline can make a notable contribution to the progress of the other.

The international aspects of most of the technical questions handled by WMO are dealt with by one of its eight technical commissions (composed of experts nominated by member countries) or by special panels or working groups of experts established by the executive committee or by the technical commissions themselves. Nearly all the experts, recruited from various countries, are prominent meteorologists. The success of this system depends entirely on the goodwill and co-operation of the member countries and the national meteorological services, and one of its significant results is that the services of practically all the world's foremost meteorologists are made available to the organization in one capacity or another.

The growing interest of WMO in atomic energy was reflected in the decision of the executive committee in 1956 to establish a panel of experts to study the meteorological aspects of this new sphere of activity. The initial tasks of the panel, were to ensure that the new techniques arising from developments in nuclear physics were wherever possible used to assist the science of meteorology and to provide advice and assistance to both WMO members and other international organizations in this field.

Two Meetings

One of the major achievements of the panel, which has held two meetings since its inception, has been the preparation of a technical note treating fully the various meteorological problems resulting from the applications of the peaceful uses of atomic energy. This technical note is now almost complete and will be available shortly. Other valuable work includes the compilation of periodic bibliographies dealing with the meteorological aspects of atomic energy and the maintenance of close collaboration with other interested international organizations, especially with IAEA.

Over the past four years, steady progress has also been made both in adapting nuclear techniques to meteorological uses and in providing advice and assistance. The five-member panel has now been reconstituted with more clearly specified responsibilities as a result of the increased understanding of the role of the organization in guiding this work at the international level which has been gained during these years. The new terms of reference of the panel give a good idea of the scope of its work as well as an indication of some of the developments which may result from their studies. They may be summarized briefly as follows:

(*a*) To work out a programme on the application of atomic physics in meteorology, including the use of radioactive isotopes for the measurement of various elements, and for the provision of assistance to the members of WMO;

(*b*) To prepare technical notes and lists of references on all meteorological aspects of the peaceful uses of atomic energy;

(*c*) To study the work of other international bodies active in this field with a view to making recommendations on WMO's participation in the working out of projects in which there are significant meteorological aspects;

(*d*) To study the problems of the standardization of instruments and methods of observation for the collection of radioactivity data together with meteorological data.

Heavy Programme

It may thus be seen that the WMO panel has a heavy programme of work which should produce results of interest not only to meteorologists but also to other scientists whose disciplines affect or are affected by meteorological considerations.

In explanation of these terms of reference it should be mentioned that the interest of WMO in the peaceful uses of atomic energy can be viewed from two separate standpoints. Firstly, what help can the meteorologist give in ensuring the safe and effective utilization of atomic energy and, secondly, how can developments in atomic energy be adapted to serve the cause of meteorological progress?

One of the most important problems of the day is to ascertain the movement of both natural and artificially-injected radioactive substances in the atmosphere. In recent years, this problem has largely centered round the need to measure the atmospheric pollution caused by nuclear explosions in order to assess the potential danger to life of all kinds. Since the movement of radioactive substances in the atmosphere is essentially dependent upon meteorological factors, including the winds at various levels, vertical movements in the atmosphere, rainfall and the stratosphere-tropospheric interchange, the advice of the meteorologist on the physical processes controlling these factors is evidently vital. Much time and thought are now being devoted to the study of large-scale air mass movements, turbulent diffusion and the other meteorological processes on which the transport and gradual fall-out of radioactive debris depend. The safe location of nuclear plants and the disposal of radioactive waste are related problems in which WMO has also taken a very active interest and the importance of effective meteorological advice on these problems can hardly be over-estimated.

Analysis of the Biosphere

Another aspect of the help which WMO as an organization can provide is intimately connected with its structure. This help concerns the collection and analysis of radioactive material in the biosphere. For a variety of purposes, including weather forecasting, the countries of the world maintain in their respective territories extensive networks of meteorological stations making observations at regular intervals. At present, more than 9,000 land stations and ships participate in this work and an intricate system of telecommunications operates day and night to ensure the timely collection and distribution of the resulting vast quantity of data on the weather throughout the world. The sites of the stations, the instruments used, the methods of observation, the transmission times and other arrangements for diffusing the data are controlled by regulations or recommended practices laid down in WMO publications. It is against this background of WMO's normal activities that the possible participation of the organization in any system for the collection and analysis of radioactive material in the biosphere should be viewed.

It will be clear that WMO has at its disposal a considerable amount of information on the most suitable exposure for instruments which measure or sample atmospheric properties. It is assumed that, as for meteorological parameters, representative samples of atmospheric radioactivity will be required and for that reason WMO is prepared to assist in the arrangements for developing a network of measuring stations. Moreover, WMO and its members can provide information on the distribution of amounts, types and intensities of precipitation, which is an important factor.

It is also highly probable that on all occasions when the radioactivity of the atmosphere and of rain is being measured, there will be a requirement for the corresponding values of meteorological elements. This consideration emphasizes the advantage to be derived from taking radioactive samples at locations which are near to meteorological observing stations.

The second aspect of WMO's role in atomic energy is the application of nuclear techniques to the solution of meteorological problems. To some extent, the two roles of WMO in this field are complementary. For example, in seeking to provide data on the movement of radioactive substances in the atmosphere much valuable information on hemispherical air movements is also obtained. The problem of the general circulation of the atmosphere is receiving the closest attention at present and it is possible to use radioactive particles as "tracers" of these large-scale displacements of air in the upper atmosphere. The International Geophysical Year meteorological programme was primarily directed towards improving our knowledge of the general circulation and it is widely believed that a better understanding of its behaviour might result in revolutionary progress in weather forecasting.

Great Possibilities

Advances in nuclear physics have also opened up great possibilities for the use of radioactive isotopes in making meteorological and hydrometeorological measurements. A good deal of work has already been done in constructing new instruments based on recent techniques and a large measure of success has been achieved. One of the most widely used principles is that of the attenuation of gamma rays when traversing a medium. The application of this principle to the measurement of soil moisture, evaporation, water movement, the water equivalent of snow cover, water levels and deposits at the bottom of water basins has introduced a new standard of accuracy into these traditionally difficult measurements. The use of neutrons for obtaining soil moisture measurements is also becoming more widespread.

WMO has an important part to play in standardizing the instruments and methods deriving from these new techniques and in ensuring their adaptation to meteorological problems in the widest and most beneficial manner.

Extract from an article published by the International Atomic Energy Agency in collaboration with the WMO.

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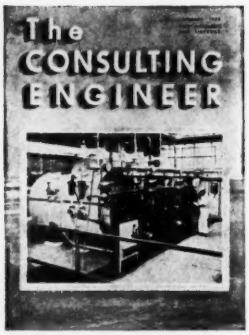

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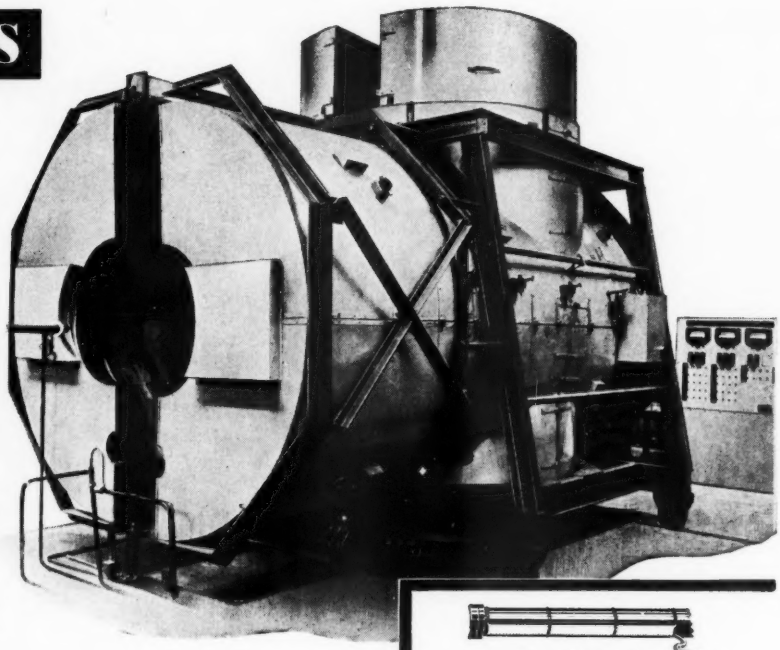

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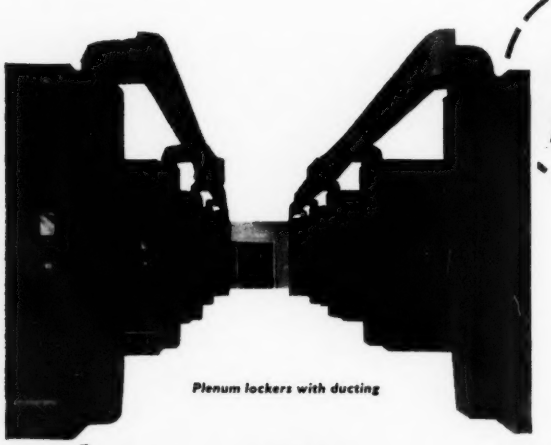

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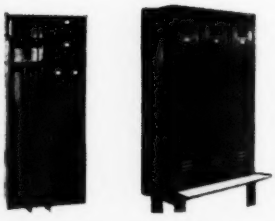

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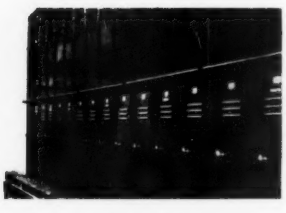

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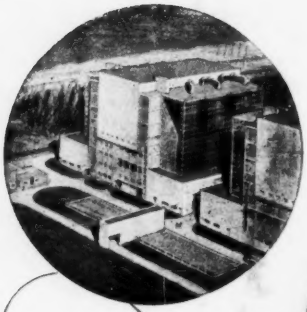

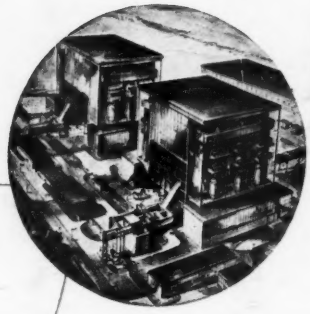

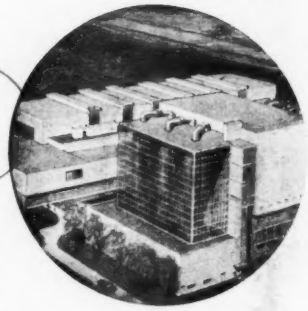

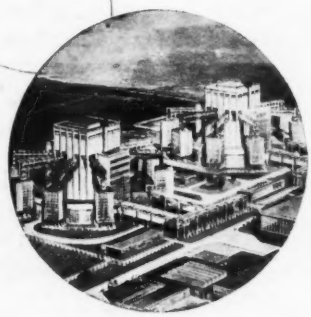

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